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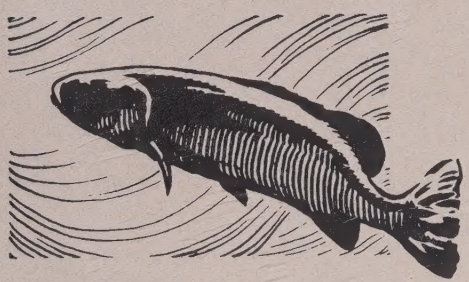

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EFFECT OF TEMPERATURE AND PHYSIOLOGICAL CONDITION ON TOLERANCE OF CHANNEL CATFISH TO PYRIDYLMERCURIC ACETATE (PMA)

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and
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THE VALUE OF PYRIDYLMERCURIC ACETATE (PMA) for controlling certain diseases and parasites of channel catfish was previously reported by Clemens and Sneed (1958). However, there are a number of factors to be considered in order to use this chemical wisely and effectively. These considerations include (1) the physiological condition of the fish to be treated, (2) the temperature of the water, (3) the possibility of delayed mortality due to chemical treatment, (4) the frequency of treatment and acquired chemical tolerance on the part of both fish and parasite, and (5) the chemical variations inherent in the chemical being used.

Other workers have investigated some of these factors in relation to trout and salmon. Allison (1957) demonstrated that different lots of pyridylmercuric acetate from the same manufacturer had different toxicity thresholds for rainbow trout. Burrows and Palmer (1949) showed that blueback salmon withstood 12 consecutive weekly treatments at concentrations of 1:500,000 (2 p.p.m.) for 1 hour. Clemens and Sneed (1958) reported that fingerling channel catfish withstood daily treatments of 2 p.p.m. for 1 hour for periods exceeding 6 weeks.

The method of bioassay employed to obtain the data of this paper is identical to that reported by Clemens and Sneed (1958). It should be remembered that 100 fish were used in each experiment, so that 10 fish were exposed to each concentration of chemical. The chemical analyses of the water reported there also apply to this paper. The only PMA used in both reports was manufactured by Mallinckrodt and bore the lot number 1483. All concentrations are reported on the basis of the material as it came from the bottle, not on the basis of active ingredients.

Relation of Temperature to Toxicity

The tolerance of fingerling channel catfish to PMA increases as the water temperature decreases. At 24° C., the median lethal dosage (LD_{50}) for an 8-hour exposure was 5.8 p.p.m.; at 16.5° C., it was 10.8 p.p.m.; and at 10° C., it was 21.1 p.p.m. This relationship existed for other exposure periods up to 153 hours (table 1). The fact that the LD_{50} at 24° C. was 34.1 p.p.m. for a 2-hour exposure suggests that a dosage of 2 p.p.m. for 1 or 2 hours should be relatively safe

This investigation was conducted under a Saltonstall-Kennedy Act contract. The University of Oklahoma Research Institute administered the contract in cooperation with the U. S. Fish and Wildlife Service. Dr. Carl D. Riggs, Director, Oklahoma Biological Survey, is the project director.

The authors are entitled to equal credit for this report.

TABLE 1.--The median lethal dosage (LD_{50}) in parts per million of PMA for fingerling channel catfish at different temperatures and intervals of exposure

Exposure (hours)	Water temperatures 10° C.	16.5° C.	24° C.
1 ---	>50	>50	>50
2 ---	>50	>50	34.09
4 ---	>50	18.25	11.86
8 ---	21.07	10.76	5.79
24 ---	5.79	2.96	[1]/ 3.75
48 ---	4.12	2.81	.49
72 ---	2.81	1.81	<.37
96 ---	2.43	<.37	<.37
121 ---	2.21	<.37	<.37
153 ---	2.02	<.37	<.37

[1]/ This apparent discrepancy is inexplicable on the basis of present data.

for use on fingerlings; and experience and numerous experiments have verified this assumption, at least when PMA of lot 1483 was used in water at Tishomingo or Norman, Oklahoma. However, we have oral reports of apparent toxicity when the same lot was used at the Federal hatcheries at Uvalde, Texas, and Dexter, New Mexico. It has not been determined whether this difference was due to water quality, the physiological condition of the fish, or other variables. The Federal hatchery at Fort Worth, Texas, has reported excellent results with 2 p. p. m. of PMA.

Tolerance of Fish of Different Ages

There appears to be some difference in the median toxicity thresholds for fish of different ages. The LD_{50} for yolk-sac fry exposed 24 hours was above 5 p. p. m.; for 1-week-old fry it was 2.18 p. p. m.; and for 3-inch fingerlings 2 months old, 3.75 p. p. m. One-week-old fry were more susceptible to PMA than either yolk-sac fry or fingerlings when exposed for 24 hours, but the difference was minimized at longer exposure periods (table 2). As this difference in tolerance at various ages was observed in work with other chemicals, it might be explained by the fact that the week-old fry were beginning to feed--a condition which may be associated with profound physiological and metabolic changes.

Condition of the Fish in Relation to Toxicity

The tolerance of fingerling channel catfish to PMA varies with the physiological condition of the fish. This was demonstrated in the following series of experiments.

The median lethal dosages for fingerling channel catfish with different histories were determined in comparable experiments conducted simultaneously. Two groups of catfish were reared in troughs: one of these groups had received PMA treatments daily for the previous 3 weeks, whereas the other had received only an occasional PMA treatment (once or twice a week). The third group had been reared in a pond and had received no PMA treatments. All fish were 2.5 to 3 inches in length and were about 5 months old.

Trough-reared fish treated daily with PMA had about the same degree of tolerance to PMA as pond-reared fish that had received no previous PMA treatments (table 3), for the LD_{50} of each falls within the fiducial limits of the other at the 95-percent level. Trough-reared fish treated

TABLE 2.--The median lethal dosage (LD_{50}) in parts per million of PMA to channel catfish of three ages

Exposure (hours)	Age of catfish and water temperature: Yolk-sac fry 23° C.	1-week-old fry 23° C.	Fingerling, 3-inch 24° C.
1 ----	>5	>5	>50
2 ----	>5	>5	34.09
4 ----	>5	>5	11.86
8 ----	>5	-----	5.79
24 ----	>5	2.18	3.75
40 ----	4.018	-----	------
48 ----	.374	<.31	.49
72 ----	<.31	<.31	<.37

TABLE 3.--The median lethal dosage (LD_{50}) in parts per million of PMA for channel catfish with different histories

Exposure (hours)	Trough-reared: Daily PMA treatments	Trough-reared: Occasional PMA treatments	Pond-reared: No PMA treatment
8-----	>3.55	<5	3.66
24-----	1.83	2.09	1.71
48-----	1.55	1.06	1.61
72-----	.84	<.32	.85
96-----	.5	<.32	.47

occasionally with PMA withstood less of the chemical than the pond-reared fish or the frequently treated fish at 48-, 72-, and 96-hour exposures, but withstood about the same amount for 24 hours. It was suspected that the fish treated less frequently were weaker from disease and parasites than the fish in the latter two categories.

If only the experiments with trough-reared fish were considered, then one might reason that the fish became more tolerant to PMA when treated daily. The experiments with pondfish that had received no PMA treatments tend to disprove this possibility; and because these fish withstood as much PMA as those treated daily, both lots of fish were considered equally healthy.

These experiments suggest that PMA is effective in controlling diseases and parasites commonly contracted in troughs. To test this idea, an additional experiment was conducted with trough-reared fish that had received different treatments of PMA. It was assumed that the experiment would provide a range of tolerance levels which would vary according to the frequency of previous exposures to PMA. Thus, the median lethal dosages of PMA were determined for fish that had received daily PMA treatments for several weeks, for fish that had received no PMA treatments, and for fish that had received only three PMA treatments the week prior to the experiment. The results in table 4 substantiate the hypothesis, as the greater tolerance to PMA was positively correlated with the greater frequencies of PMA treatments. Such treatments possibly improve the health of the fish.

In fish-cultural practices the condition of the fish to be treated is an important consideration. It is entirely possible to kill fish by the chemical treatment and, in so doing, be unable to determine whether the fish were killed by treatment or by disease. Such situations may be misleading, and the fish-culturist may too readily declare the treatment unsuccessful, as any improvement in the condition of the fish was offset by the high mortality of weak fish. The death of weak fish by overtreatment is difficult to assess, for the argument that such fish were going to die anyway is usually offered.

Delayed Mortality

An epidemic of Amphileptus was found in 1 trough of 3-week-old channel catfish. About 50 of these fish were placed in each of 11 aquaria of 15-liter capacity. In this manner, fish were exposed to 5, 4, 3, 2, 1, and 0 p.p.m. of PMA for 4.5 hours. Another series of the same fish was exposed to identical concentrations for 1 hour, after which the fish were placed in fresh water. The fish exposed to PMA for 4.5 hours at 23° C. showed the mortalities listed in table 5.

The series exposed to the PMA for 1 hour showed no greater mortality at any

TABLE 4.--The median lethal dosage (LD_{50}) in parts per million of PMA for channel catfish raised in troughs and exposed to different PMA treatments prior to the experiment

Exposure (hours)	Daily PMA treatments	Three PMA treatments previous week	No PMA treatment
8-----	>5	>5	4.8
24-----	4.5	2.77	1.83
48-----	2.9	.75	.54
72-----	.72	<.32	<.32
96-----	>.32	<.32	<.32

concentration of PMA than was present in the controls. Since all of these fish were living at the end of the treatment, it can be said that a 4.5-hour exposure at the higher concentrations of PMA caused a delayed mortality that was apparent within 24 hours but not beyond this time up to 96 hours, when the experiment was terminated. Additional experiments were conducted with week-old fry at the same concentrations for 1- and 2-hour exposures, and no delayed mortality was observed.

TABLE 5.--Delayed mortality of 3-week-old fry exposed to various concentrations of PMA for 4.5 hours

	Concentrations of PMA in p.p.m.					
	5	4	3	2	1	0
Percentage mortality in						
first 24-hour period----	50	19.2	13.9	5.2	0	2.4
second 24-hour period---	3.6	0	0	0	0	0
third 24-hour period----	3.6	0	0	0	0	0
fourth 24-hour period---	0	0	0	0	0	0

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HAULING AND HANDLING OF HATCHERY TROUT

An experiment was conducted from May 12 to May 27, 1958, to test early post-planting mortality as affected by the weight of trout carried in tank trucks, length of haul and hauling time, and the amount of handling sustained by the trout prior to actual release in the stream. Two lots of catchable-size rainbow trout (light and heavy loads) received from Fish Springs Hatchery and two similar lots from Moccasin Creek Hatchery were used. The results indicated that:

1. Trout transported in light loads (150 pounds) such as are delivered to Convict Creek for experimental purposes have no measurable advantage--in terms of survival--over trout carried in heavy loads (300 to 350 pounds) hauled during routine stocking operations in 150-gallon tanks mounted in pickup trucks.

2. Handling, hauling (drugged with sodium amytal, and undrugged), anesthetization (chlorobutanol) for marking, weighing, and measuring--when carefully conducted--have no appreciable effect on the early mortality of initially healthy and robust trout.

3. A long haul (12.5 hours) of a light or heavy load is no more likely to result in so-called delayed planting mortality than a short haul (1.75 hours) at the same load level--again assuming that the trout were in good physical condition and were properly handled.

---REED S. NIELSON, Bureau of Sport Fisheries and Wildlife, Reno, Nevada.

MODERN FISH PASSES IN THE NETHERLANDS

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UNTIL THE TWENTIES OF THIS CENTURY a huge number of fishes populated the River Meuse or used it as a road to their spawning grounds. Among these, salmon, sea-trout, and eels were the most valuable species, giving rise to a fishery of economic importance.

For navigation purposes seven weirs of the overflow type were built in the Dutch part of the Meuse about 1930. It was then decided that fish passes should be constructed simultaneously with the weirs. At that time the salmon only was regarded as a really important species, and hence the passes were designed with the intention of facilitating the salmon migration only.

Therefore, Denil and pool-type passes were constructed in conjunction with the weirs. Contrary to expectations, the salmon did not succeed in making use of these passes. This finally led to complete annihilation of the salmon population and serious destruction of the stocks of eels and other species which escaped complete annihilation because some managed to pass the weirs by using the ship locks. This disaster is the more to be regretted because the Meuse is virtually the only unpolluted river in the Netherlands and is eminently suited biologically for a profitable fishery.

Repeated complaints from anglers and from professional fishermen ultimately led to the decision that the fish-pass problem should be reconsidered but now from the biological point of view. One desired now to develop a pass suited not only to salmon migration but also for the use of other fish species occurring in the River Meuse.

Consideration

In our opinion two items are of extreme importance to the satisfactory working of a fish pass: (1) the situation of the entrance and (2) the type of the pass.

The present passes in the River Meuse have their entrance alongside the weirs, their discharge directed parallel to the flow of the river. This is an unsuitable feature because division of a river into a narrow stream flowing alongside a broader one in quite the same direction will not lead to an essential change in the general current pattern, liable to be perceived by the migrating fish. We assume, on the contrary, that for efficient functioning the final path the water has to follow in the fish pass should form a right angle with the direction in which the river flows and be situated just downstream of the point where the turmoil of the water falling over the weir finishes. Fish migrating upstream will be alerted by the turmoil, hesitate downstream of it, and thereby have a fair chance to detect the water quietly flowing out of the fish pass from quite a different direction.

Apart from our demand that even the tiniest fishes must be able to make use of a fish pass, we are strongly of the opinion that the pass is also for the more powerful migrants, e.g., the salmon. It is of considerable advantage to make their passage through weirs as easy as possible. Any serious obstacle may affect the condition

of the fish and may lead to a diminished urge to migrate. If a given type of fish pass can be used only by the expenditure of considerable effort, a series of such passes may, through their accumulative effect, form an unsurmountable barrier, especially for those migrants with the weakest migration urge. In these terms, rumors that a series of fish passes in some rivers brings about a segregation of salmon sexes can be plausibly explained, as the sexes differ in migration urge.

Another drawback of a labor-demanding fish pass is that, from the observation that some migrants do make a successful use of the fish pass, one should not conclude that the whole stock assembled in front of a weir will be in a position to proceed upstream. There is always the possibility that only the strongest specimens do succeed, and this may lead to a serious reduction of the number of fish reaching the spawning grounds.

Therefore, it was decided that the fish passes would be constructed in such a way that the fish need not surmount the difference in water level by their own efforts; instead, they would be lifted to the higher level, and it seemed most convenient to have that achieved by the water itself. In order to reach this goal, the ship-lock system--the principles of which are well known--was chosen, this being operated electroautomatically.

One of the Meuse fish passes (that at the weir at Lith) has already been converted into a fish lock despite considerable costs. Underwater observations made in a specially designed room revealed that, really, all the fish species inhabiting the river--down to the three-spined stickleback, and down to even the tiniest individuals--made use of the pass with complete success and obviously without exertion.

The enormous advantage of the lock system is that the height of the weir (i. e., the difference in water level at both sides of the weir) is no more of any importance to the fish. This is in striking contrast to the commonly used pool-type pass. The correctness of this statement has been demonstrated in practice by the construction of a fish pass, 20 meters high, of the lock system at the hydroelectric weir in the River Liffey at Leixlip near Dublin. It has been stated (Murphy and Dodge 1951) that the automatically operated lock functions here in a most efficient way for all fish species. Here, too, the fish are lifted by the water, which renders it unnecessary for them to expend much effort.

Until now we have discussed the biological side of the fish lock; but apart from the biological suitability there are some technical advantages, too. These are really worth mentioning, at least when the corresponding weir has not yet been constructed. Most of the weirs are planned as a part of a hydroelectrical scheme, which demands as great a difference in water level as possible. Should the levels at both sides of the weir be connected by a pool-type fish pass, then the pass must necessarily be of considerable length, stretched along the bank of the river, and has to be constructed over a great distance beyond the weir. This will involve considerable expense.

On the contrary, a fish lock can be built in the weir itself, as a sort of tube, running parallel to the downstream-slanting side of the weir. The space required can be left free in the concrete mass; hence the construction of it will not incur sizable costs. Moreover, it has been ascertained that a fish lock spills considerably less water than a pool-type pass would under the same conditions. From a hydroelectrical point of view, this is an important feature.

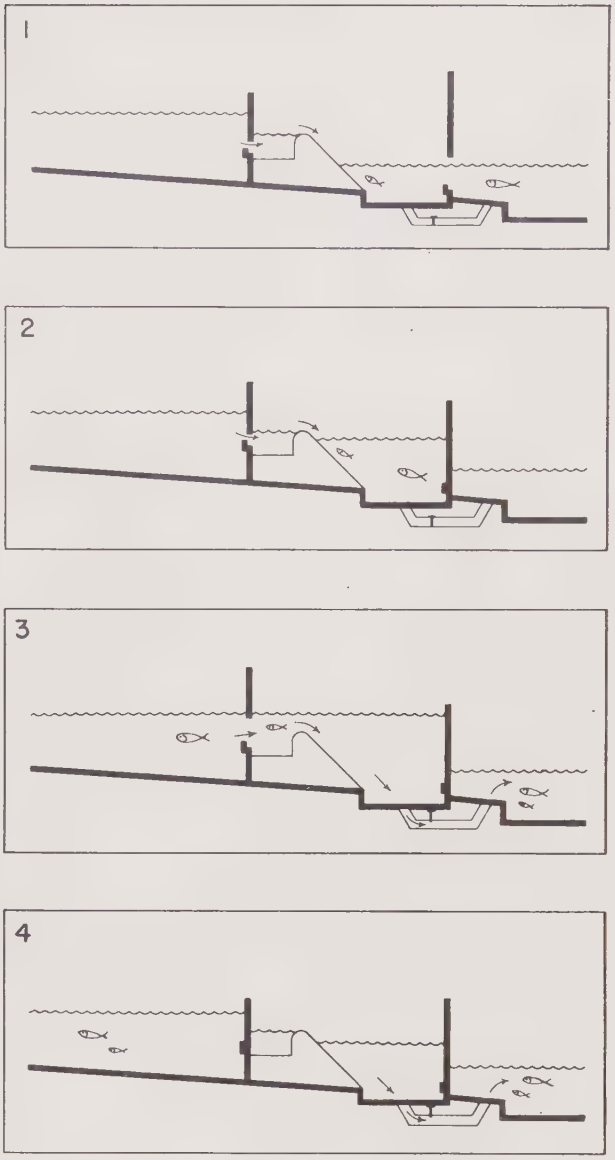
Short Description of the Meuse Hydraulic Fish Lock at Lith

This particular fish pass can be considered as a narrow canal with slanting bottom. Part of the canal functions only as a lock, this section being enclosed between hatches--which can move up and down--at its upper and lower ends. In the lock itself a concrete body has been formed with the intention of diminishing the volume of the lock so that it may fill quicker when in use. This body has a side

slanting downstream so that water flowing over the top rushes down; in fact, a sort of spillway is created. It has appeared that water flowing down obliquely in this particular way greatly attracts the migratory fish. We cannot yet explain just why. Perhaps it creates a special kind of turbulence which is preferred by fish.

Stages in the operation of this fish lock are delineated in the four sketches presented here. In the first stage the lower hatch is opened and the upper hatch is manipulated in such a way that a small amount of water rushes into the lock (1). By this procedure the fish are strongly attracted to enter the lock and to assemble at the foot of the concrete body. Then the lower hatch can be closed so that no water can leave the lock--which leads to its gradual filling (2). When the water level in the lock is equal to that of the river upstream of the weir, the upper hatch is opened completely. In this stage no fish will leave the lock, as there is no flow to guide them. Therefore, some water is now discharged at the bottom end of the lock; the water will flow out here and be replaced immediately by water flowing in at the upper end (3). As soon as this flow comes into existence, fish will begin to move upstream and consequently leave the lock. When there are no fish remaining in the lock, the upper hatch is lowered completely so that the lock will be emptied by the continuous discharge at the bottom end (4). Finally, when the water in the lock has reached the downstream level, the lower hatch may be reopened--after which the whole procedure may be repeated.

As the difference in water levels at both sides of the weir at Lith is rather small (about 4 meters), the fish pass could be designed as a sort of open canal. With greater differences in water level, it is advisable to select a tube-shaped canal. Such a tube is of no disadvantage to the migrating fish, as has been demonstrated by the Leixlip fish lock.



Stages of operation of the hydraulic fish lock at Lith.

Conclusion

In the Dutch River Meuse an inefficient fish pass of the pool type has been converted into a fish lock. The latter is operated with great success. Fish which enter this lock are transported upward by a rising water level without being forced to expend any considerable labor themselves.

It has been pointed out that the fish locks not only are highly efficient from the standpoint of biologists but also offer certain technical and financial advantages in their construction. Moreover, the fish

locks can be used over any differences in water level, as far as one can see.

We therefore strongly recommend that the inefficient types of passes be discarded and that only fish locks be constructed in future.

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1951. The hydraulic fish lift at Leixlip. Bull., Inst. Civil Engineers of Ireland 77 (3): 61-88.

EFFECTS OF EXPLOITATION ON FISH POPULATIONS

Four guppy populations in aquarium tanks were held for 168 weeks under identical conditions of space, light, temperature, and food supply. During the last 128 weeks of this period, two of these populations were subjected to successive exploitation rates of 25, 10, 50, and 75 percent per reproductive period (3 weeks).

Exploitation at these rates produced major changes in number for both test populations--changes not duplicated in the controls. The 25-percent rate caused an initial decrease in number of adults, followed by an increase in number of juveniles. The 10-percent rate resulted in an increase in number of adults, followed by a decrease in number of juveniles. The changes at the 50-percent rate resembled those appearing at the 25-percent rate but were more extensive. After application of the 75-percent rate, both juveniles and adults declined rapidly until they were extinct.

The changes in weight recorded for the test populations resembled the changes in number, but the fluctuations were less violent. The changes in weight of catch after the increase from 10- to 50-percent exploitation followed classical conceptions derived on theoretical grounds.

Equilibrium yield--average yield during 6 weeks without significant unidirectional changes in population composition--was so related to fishing rate as to indicate maximal yield at fishing rates between 30 and 40 percent, when populations were at about one-third of their asymptotic level.

The yield of fish flesh at the maximum indicated that about 20 percent of the food consumed was converted into fish flesh.

Catch, catch per unit of effort, and average fish length were sources of valuable information about population size and results of changes in fishing rates. Catch per unit, in particular, followed changes in size of population.

Full details appear in "Experimental Exploitation of Fish" by R. P. Silliman and J. S. Gutsell, U. S. D. I., Fish and Wildlife Service, Fishery Bulletin 133.

New and deadly strains of Chondrococcus columnaris--mutants derived from ordinary strains--have appeared with increased water temperatures in the Columbia River system. These mutant strains have been so "hot" that they killed young salmon in less than 24 hours after being introduced into the water where the fish were held.

In rearing pools at Cades Cove in Great Smoky Mountains National Park, carp and longear sunfish exhibited an ability to survive exposures to 1 or more p. p. m. of rotenone for periods of as much as 6 hours.

TOXICITY OF ENDRIN TO FISH

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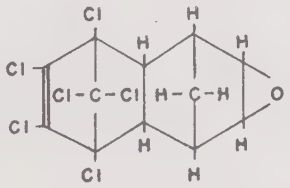
INSECTICIDES are indispensable for modern farming, but some of them have harmful effects on fish. This problem cannot be disregarded, especially in Japan, because fish culture is carried on in areas adjacent to paddy-fields. There are few reports about field work on the effects of insecticides on fish, although a number of investigations have been made in the laboratory.

In the hope of obtaining some knowledge on the problem, the present authors performed experiments on the toxicity of Endrin to fish in the fields as well as in the laboratory. Endrin is one of the insecticides most harmful to fish.



These experiments were conducted at Anzyo, Aiti Prefecture, from spring to autumn of 1957. Three forms of Endrin--emulsion, dust, and granule--were examined. The concentration of the insecticide is noted in parts per million or grams per tan, active ingredient, in the present paper.

Laboratory Experiments

Relation Between Toxicity and Temperature

The relation between the toxicity of an emulsion of Endrin to fish and water temperature was examined. Tests were conducted chiefly on young carp (Cyprinus carpio). For supplementary experiments young goldfish (Carassius auratus) and adult water fleas (Moina macrocopa, food for fish) were used. The fish were exposed to a small series of solutions containing Endrin in logarithmically increased quantities. Each series was placed in a glass container kept at a constant temperature during the experiment. Five fish were placed in a 2-liter glass jar, and 10 to 35 fish were tested at each concentration at each temperature. The toxicity was expressed as median tolerance limit (equivalent to LD_{50}), according to Doudoroff (1951). The results are summarized in table 1.

Change of Median Tolerance Limit in Course of Development of Fish

Fujiya (1955) showed that the fertilized egg of carp is more resistant to Endrin than the fry at 5 days, 3 weeks, 6 weeks, and 3 months after hatching. The present authors intended to obtain more data on the problem, especially in the early stage of development.

Fertilized eggs and larvae of carp and snakehead fish (Channa argus) were used in the experiment. The method was generally similar to that already described. The results are shown in table 2.

Field Experiments

Residual Toxicity of Endrin Applied in the Paddy-Fields

Three forms of Endrin--emulsion, dust, and granule--were examined. In

TABLE 1.--Median tolerance limits for Endrin at various water temperatures

Water temperature (°C.)	Median tolerance limit 24 hours (p.p.m.)	Median tolerance limit 48 hours (p.p.m.)	Animal	Body length (cm.)	Number of animals used
7 - 8	0.42	0.14	Carp	5 - 7	50
17 - 18	0.03 - 0.009	0.008 - 0.004			150
27 - 28	0.005	0.005			95
27 - 28	0.003	0.002	Goldfish	4 - 5	40
20	3.2	0.056	Water flea	-----	100

the first experiment, each concentration spread in the field was 100 grams of active ingredient per tan (0.245 acre); in the second experiment, 200 grams per tan.

For each experiment the insecticide was employed after the water in the field was almost drained away. On the day after that on which the insecticide had been applied, each field was filled with water.

The toxicity of Endrin was examined in the following way: 5 wire cages (6 by 12 by 9 inches) were placed in each test field--1 cage at each of the 4 corners and 1 cage in the center of the field. In this study, hollows 2 inches deep were dug in the field and each cage was placed in a hollow. One to two inches of mud was added to the bottom of the cage in order to protect the fish from heat. The fish could creep or hide in the mud, the temperature of which was always 3° to 4° C. lower than that of the water. For further protection from direct sunshine, each cage was covered with a wooden plate.

Three fish (two carp and one goldfish, or three carp, 4 to 6 centimeters in body length) were placed in each cage. During this experiment no difference in the effects of Endrin on carp and goldfish was observed.

After the fish were placed in the cages, the number of dead or moribund fish was counted at intervals. These numbers were used as a measure to indicate the residual toxicity of Endrin in the water.

TABLE 2.--Median tolerance limits for Endrin at various stages of development

Developmental stage	Carp: Median tolerance limit (24 hours 20° C.)	Carp: Number of animals used	Snakehead fish: Median tolerance limit (24 hours 20° C.)	Snakehead fish: Number of animals used
Fertilized egg (early stage)	-------	---	92	60
(later stage)	19.9	80	100	84
Larva (about 1 day after hatching)	8.5	100	62	94
(about 2 days after hatching)	10.7	124	13.5	93
(about 3 days after hatching)	4.9	61	15.5	94
(about 4 days after hatching)	4.2	41	5.6	146
(about 5 days after hatching)	.061	30	-------	---
(about 6 days after hatching)	.046	16	.012	160
(about 12 days after hatching)	------	---	.0065	83

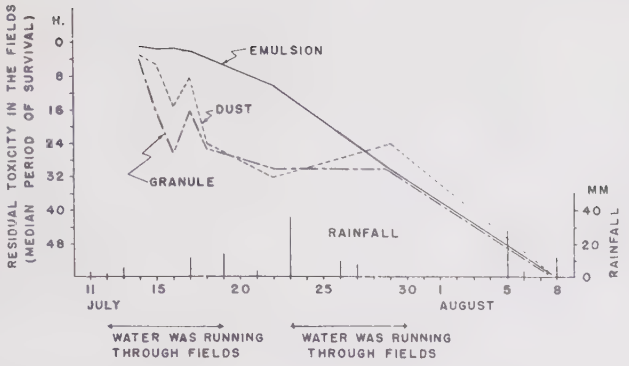


FIGURE 1.--Residual toxicity in the paddy-fields: the first experiment.

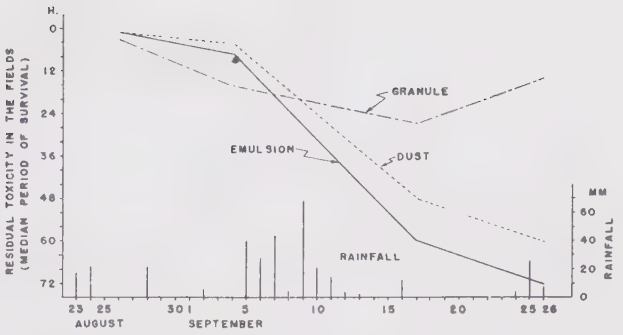


FIGURE 2.--Residual toxicity in the paddy-fields: the second experiment.

The area of each test field was approximately 1 tan (0.245 acre).

Results

Two experiments were conducted: the first was started on July 11, 1957, and the second on August 23, 1957.

In the first experiment water was always allowed to run through the test field during the experimental period except for 3 days when urea, a kind of fertilizer, was applied. The flow of water was about 80 to 150 liters a minute.

The results of the first experiment are summarized in table 3 and figure 1. In figure 1 the residual toxicity in the paddy-field is shown as median period of survival in hours (coordinate). Thus, on July 29 half of the fish in the cages died or were moribund in 24 to 30 hours after they were put in the cages. In each study 15 fish were used in each test field, but 3 of them were always near the entrance of uncontaminated water. Therefore, the 3 did not die in any instance; hence we omitted them from table 3. All fish in the control field were always healthy.

On August 8, 28 days after application of the insecticide, 1 of 12 fish was affected by emulsion, 1 was affected by dust, and 3 were affected by granules (table 3).

Although the residual toxicity was very slight on the 28th day, we cannot help recognizing that the toxicity may remain in the field even about a month after application of the insecticide in various forms.

In the second experiment the test fields were managed in the ordinary manner; i.e., the water supply, weeding, and other processes in the test fields were the same as those in the fields of ordinary Japanese farmers. Generally speaking, water was always supplied to maintain the water level of the test fields. The results of the second experiment are summarized in table 4 and figure 2. As in the first experiment, the fish in the cage near the entrance of the uncontaminated water were omitted from the table because they were always normal.

As seen in table 4, a considerable number of fish in the control field died. The reason is that the water which had flowed from the dusted field entered the control field and thus contaminated it.

It may be concluded that the toxicity of Endrin remains for more than 1 month. The toxicity of Endrin in the granule form tends to remain longer than that of the dust and emulsion forms. This tendency may also be seen in the first experiment (table 3, last column).

This study of the toxicity was terminated on September 26 because the water was drained from all the fields on that day.

Toxicity of Effluent From Endrin-Treated Paddy-Field

The toxicity of the water flowing from the Endrin-treated field was examined in the same way. Two series of experiments were conducted: the first was started on

TABLE 3.--The residual toxicity of Endrin to fish when it is applied in the paddy-field: the first experiment

[The numerator in each fraction in the table is the number of fish dead or moribund from toxicity; the denominator is the number of fish tested.]

Days after application:	3 days					4 days								5 days				
Hours after fish are put in:	2	4	6	9	24	3	8	24	28	32	48	52	56	3	7	24	28	33
Type of Endrin:																		
Emulsion	12/12	--	--	--	--	9/12	12/12	--	--	--	--	--	--	9/12	12/12	--	--	--
Dust	0/12	12/12	--	--	--	1/12	10/12	12/12	--	--	--	--	--	0/12	2/12	12/12	--	--
Granule	0/12	7/12	9/12	9/12	10/12	1/12	4/12	6/12	6/12	7/12	8/12	9/12	10/12	0/6	0/6	3/6	3/6	6/6
Control	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15

Days after application:	6 days			7 days			11 days					18 days					28 days			
Hours after fish are put in:	4	8	24	4	8	24	16	24	41	48	64	16	24	30	48	62	6	24	30	48
Type of Endrin:																				
Emulsion	12/12	--	--	5/12	7/12	12/12	9/12	11/12	12/12	--	--	2/12	4/12	7/12	10/12	12/12	0/12	0/12	1/12	1/12
Dust	0/12	9/12	12/12	0/12	0/12	6/12	0/12	2/12	10/12	10/12	10/12	4/12	6/12	11/12	11/12	12/12	0/12	0/12	1/12	1/12
Granule	1/5	2/5	5/5	0/10	0/10	3/10	1/12	5/12	8/12	8/12	8/12	0/12	4/12	7/12	9/12	9/12	0/12	0/12	1/12	3/12
Control	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15

TABLE 4.--The residual toxicity of Endrin to fish when it is applied in the paddy-field: the second experiment

[The numerator in each fraction in the table is the number of fish dead or moribund from toxicity; the denominator is the number of fish tested.]

Days after application:	3 days			12 days						25 days					
Hours after fish are put in:	2	4	18	3	6	8	24	32	48	6	24	30	48	72	96
Type of Endrin:															
Emulsion	9/12	9/12	12/12	0/12	3/12	9/12	9/12	9/12	9/12	0/11	3/11	3/11	5/11	10/11	10/11
Dust	7/12	12/12	--	0/12	8/12	12/12	--	--	--	0/12	2/12	3/12	6/12	10/12	12/12
Granule	2/12	7/12	9/12	0/12	0/12	0/12	9/12	9/12	9/12	0/12	4/12	7/12	12/12	--	--
Control	0/15	1/15	12/15	0/15	0/15	0/15	1/15	5/15	9/15	0/15	0/15	0/15	0/15	0/15	1/15

Days after application:	34 days								
Hours after fish are put in:	5	24	30	48	72	96	120	144	168
Type of Endrin:									
Emulsion	0/12	4/12	4/12	4/12	6/12	6/12	6/12	7/12	11/12
Dust	0/12	4/12	5/12	5/12	7/12	10/12	11/12	12/12	--
Granule	0/12	8/12	12/12	--	--	--	--	--	--
Control	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15	0/15

July 24, 1957, using Endrin in the form of granules; the second was started on August 28, 1957, using three types of Endrin. The second part of this experiment was conducted in the stream adjacent to the paddy-fields that were used in the second experiment of the preceding section.

(Right)

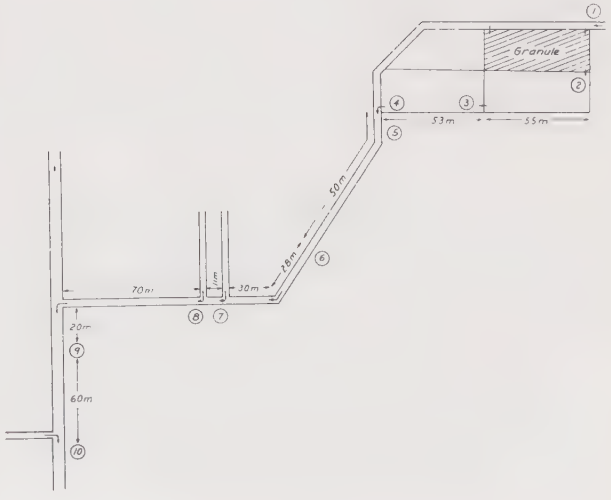


FIGURE 3.-- Waterway from the test field: the first experiment. Figure in circle shows the station number. Arrows show the direction of water.

TABLE 5.--Toxicity of the water flowing out of the paddy-field treated with granular Endrin: the first experiment

[The numerator in each fraction in the table is the number of fish dead or moribund from toxicity; the denominator is the number of fish tested.]

Days after application:	1 day												
Hours after fish are put in:	5	20	28	41	48	72	96	120	144	168	192	216	240
Station:													
1 (Control)	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
2	0/3	3/3	--	--	--	--	--	--	--	--	--	--	--
3	0/3	3/3	--	--	--	--	--	--	--	--	--	--	--
4	0/3	3/3	--	--	--	--	--	--	--	--	--	--	--
5 to 10	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18

Days after application:	1 day (continued)				2 days		3 days		5 days		13 days			
Hours after fish are put in:	264	288	312	336	18	24	18	24	9	24	8	24	31	48
Station:														
1 (Control)	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
2	--	--	--	--	3/3	--	3/3	--	3/3	--	0/3	1/3	3/3	--
3	--	--	--	--	1/3	3/3	3/3	--	1/3	3/3	0/3	0/3	0/3	0/3
4	--	--	--	--	?	?	0/3	3/3	3/3	--	0/3	0/3	0/3	0/3
5 to 10	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18	0/18

In the first experiment for this study, granules of Endrin were spread in the 1-tan field. The concentration was 100 grams of active ingredient per tan. The waterway from the field is shown in figure 3. The results of the experiment are summarized in table 5.

In the stations below station 4 (about 100 meters from the contaminated field), no fish died in 2 weeks. This shows that the dilution at station 5 was enough to decrease the toxicity. It can be assumed from previous experiments that the toxicity at station 2 would remain for more than 1 month.

In the second experiment, the stream adjacent to the three fields treated with granules, dust, and emulsion of Endrin

TABLE 6.--Toxicity of the water flowing out of the paddy-fields treated with three forms of Endrin: the second experiment

[The numerator in each fraction in the table is the number of fish dead or moribund from toxicity; the denominator is the number of fish tested.]

Days after application:	6 days			12 days						25 days					
Hours after fish are put in:	24	48	72	2	5	8	24	32	48	6	24	30	48	72	96
Station:															
1 (Control)	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
2	0/3	0/3	3/3	0/3	0/3	0/3	1/3	3/3	-	0/3	0/3	0/3	0/3	0/3	0/3
3	1/3	3/3	-	0/3	0/3	0/3	2/3	3/3	-	0/3	0/3	0/3	0/3	0/3	0/3
4	3/3	-	-	0/3	0/3	1/3	3/3	-	-	0/3	0/3	0/3	2/3	3/3	-
5	3/3	-	-	0/3	0/3	1/3	3/3	-	-	-	-	-	-	-	-
6	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3

Days after application:	34 days								
Hours after fish are put in:	5	24	30	48	72	96	120	144	168
Station:									
1 (Control)	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2
2	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
4	0/3	0/3	0/3	0/3	0/3	0/3	1/3	1/3	1/3
5	-	-	-	-	-	-	-	-	-
6	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3

was examined. The concentration used for this work was 200 grams per tan, and the area of each field was about 1 tan (figure 4).

The results are summarized in table 6. Toxicity at station 4 was highest because all the contaminated water from the three Endrin-treated fields came to that station.

Summary

1. Endrin becomes less toxic to fish as the temperature of the water is lowered.

2. Eggs and larvae of fish are far more resistant to Endrin than adults.

3. When Endrin is applied in a paddy-field, its toxicity to fish may remain for more than a month. The toxicity of the granule form seems to remain longer than that of dust or emulsion.

4. When Endrin was spread in 1 to 3 tan (0.245 to 0.735 acre) of paddy-field, the toxicity to fish was recognized in the adjacent stream area, about 100 meters from the treated field. The toxic effects may differ according to the conditions of the waterway from the field.

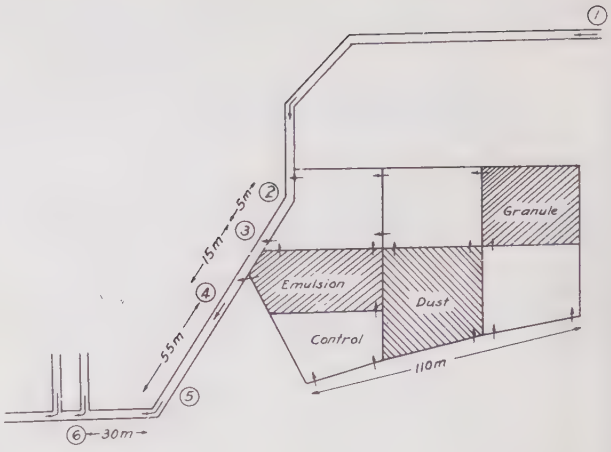


FIGURE 4.-- Waterway from the test field: the second experiment. Figure in circle shows the station number. Arrows show the direction of water.

Acknowledgment

The authors desire to acknowledge the assistance rendered in this work through a grant from the Velsicol Corporation.

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FISHING REGULATIONS IN A NEW ZEALAND LAKE

For some time the season for trout fishing in New Zealand's Lake Tutira had been a period of frustration for anglers, as they were successful only at the beginning or end of the season. The development of a dense growth of plankton and the warming of the water during the summer were favorable to the fish, not the angler.

In August 1956, the technical field officer made a survey of spawning at the lake's only tributary used for spawning. This investigator concluded that there was adequate spawning and that the population would stand greater exploitation. The local society accepted his conclusions and took the steps necessary to put his recommendations into effect. Lake Tutira was opened for a full year's fishing, and the angler was required to have a license and a permit so that the species, size, and time when the fish were caught could be determined. On the basis of these data, it should be possible to set seasons to give a maximum exploitation of the stock at a period when anglers could readily catch the fish.

More than 80 fish averaging 3.5 pounds were caught during the winter season. A survey of spawning at the end of August 1957 showed that winter fishing had had almost no effect on the trout population in Lake Tutira.

NOTES ON THE FECUNDITY OF SILVER SALMON *(ONCORHYNCHUS KISUTCH)*

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A REVIEW by Rounsefell (1957) indicated a scarcity of published data on the fecundity of North American salmonids. During the fall of 1953 and early winter of 1954, a total of 151 silver salmon (Oncorhynchus kisutch) were taken in the hatchery trap at the University of Washington.[1/] The eggs from 63 of the 65 females in the run were maintained in the hatchery as separate lots. These females were all marked fish of the 1950 brood year[2/] planted at the University of Washington in 1952 (Donaldson and Allen, in press). By maintaining the eggs as separate lots, it was possible to establish a relationship between numbers of eggs and size of fish based on individual fish; to study the relationships between size of egg, size of fish, and numbers of eggs; and to note any changes in fecundity with progression of the run.

[1/] Allen, G. H. Migration, distribution and movement of Puget Sound silver salmon. Ph.D. thesis, 1956. University of Washington. Obtainable on microfilm from Dissertation Abstracts at University of Michigan, Ann Arbor.

[2/] The brood year (or brood) is designated by the fall of the year in which the adults migrated to the spawning grounds; thus silver salmon returning in the fall of 1953 and winter of 1954 give rise to the 1953 brood year.

University of Washington, School of Fisheries, Contribution No. 39.

Estimates of the number of eggs in each lot were made during the eyed-egg stage after "bumping." Egg enumeration was made by a modification of the Von Bayer volume-displacement technique. For each lot of eggs, the total settled volume (in fluid ounces) and the number of eggs filling a 12-inch trough were determined. These data were then converted into the estimated number of eggs in the lot by using a table prepared by L. R. Donaldson, it being an extension of the Von Bayer egg-counting table to larger eggs (Lagler 1956: 190). To this estimated number of eggs were added all previously recorded mortalities in the lot in order to obtain the number of eggs produced by each female (table 1).

Burrows (1951) indicated that an overestimation of 10 percent might be expected in enumerating eggs by the Von Bayer method. Two lots of eggs which were counted twice showed variations of 5.3 and 10.4 percent between the two estimates. A third lot showed that the total number of eggs was overestimated by 4.8 percent. This was determined from a comparison of the number of fry produced (only 10) with the estimated number of fry which should have been produced as based on the estimated number of eggs calculated for the lot.

Number of Eggs Compared With Size of Female

A relationship of the form $Y = aX^b$ (where Y is the number of eggs produced

and X is the fork length of individual female silver salmon) for the 1950 brood year at the University of Washington was calculated by the method of least squares. The relationship in its logarithmic form is log Y = -0.6861 + 2.3142 log X and is shown with the individual points in figure 1. The relationship in the curvilinear form is included in figure 2.

Shapovalov and Taft (1954) calculated a fecundity relationship for silver salmon from Scott Creek, California, using 29 actual counts and 36 estimates of eggs from individual fish. The estimates were from fish of known length and involved the use of the amount (volume) of eggs and size (diameter) of eggs in samples of eggs deposited in the creek by the fish. From 18 points representing the average number of eggs produced by female fish that fell within centimeter intervals, the following length-fecundity relationship was calculated: $Y = 0.01153X^{2.9403}$. This curve is of the same shape but lies below that found for the University of Washington salmon (figure 2).

The most recent data on the fecundity of silver salmon may be found in Salo and Bayliff (1958). A dry-weight method of egg enumeration was employed.[3/] Three 1-pound samples of dry eggs were selected from the early, middle, and late portion of a day's take of eggs. The number of eggs in the 3 pounds of eggs was then determined by hand-counting. This count was used to convert the total weight of eggs taken during the day into numbers.

TABLE 1.--Fecundity of silver salmon of the 1950 brood year returning to the University of Washington in the 1953-54 migratory season.

Fork length (cm.)	Average diameter (in.)	Number of eggs	Fork length (cm.)	Average diameter (in.)	Number of eggs
65	0.293	3,420	74	0.290	4,600
67	.293	3,900	52	.261	2,200
64	.279	4,040	66	.296	2,980
69	.293	4,680	71	.312	3,840
60	.293	2,630	66	.308	3,170
67	.286	3,330	73	.286	4,730
60	.203	2,470	63	.300	2,940
49	.273	1,750	74	.308	3,200
75	.308	3,720	61	.279	2,760
71	.300	4,080	71	.304	3,550
71	.293	4,190	73	.300	4,270
69	.283	3,710	72	.279	5,700
62	.276	2,790	67	.293	3,380
67	.300	3,420	70	.293	3,864
67	.273	4,100	67	.308	3,014
44	.255	1,440	61	.300	2,520
55	.279	2,190	73	.290	4,330
58	.261	2,560	60	.267	2,910
55	.279	2,170	59	.300	1,850
59	.267	2,650	67	.296	3,240
61	.308	2,180	73	-----	3,940
68	.293	3,660	65	.261	3,730
73	.286	5,000	65	.282	2,870
53	.267	2,290	64	.282	3,970
48	.293	1,690	71	.300	3,470
51	.267	2,000	58	.286	2,470
67	.293	3,280	52	.279	1,830
56	.286	2,070	62	.273	3,440
56	.293	1,840	46	.261	1,510
57	.300	2,570	59	-----	1,840
71	.300	4,770	60	.279	1,820
			64	.286	3,330

In the 1937 and 1939 runs, all females spawned during the day were measured (standard length). From the average length of the females and the average fecundity calculated for each day, straight-line length-fecundity relationships were calculated as follows: Y = -2596 + 84.53 X (1937) and Y = -2751 + 83.74 X (1939). The curves are shown in figure 2.

Relationships Involving Size of Eggs

The nonspherical nature of the salmon egg can be a source of error in obtaining the average diameter of the eggs by use of

3/Personal communication from E. O. Salo in 1958. The method of egg enumeration used at the Minter Creek station and described above was inadvertently omitted from Salo and Bayliff (1958).

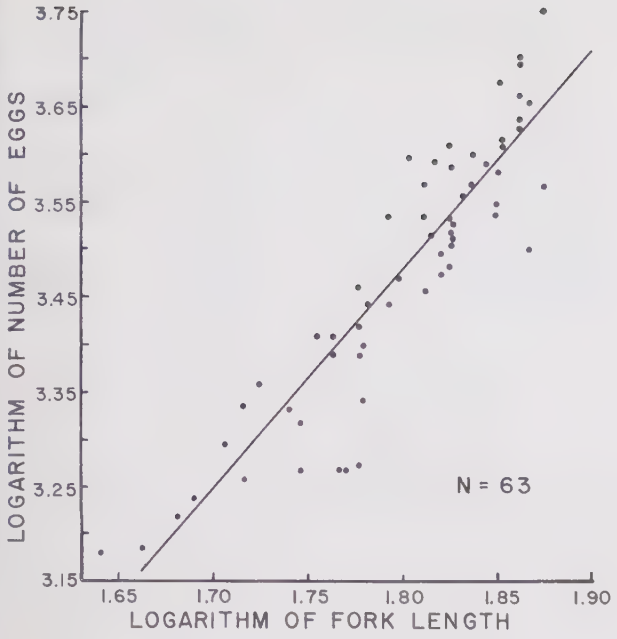

FIGURE 1.--Relationship between number of eggs and lengths of individual female silver salmon at the University of Washington in 1953.

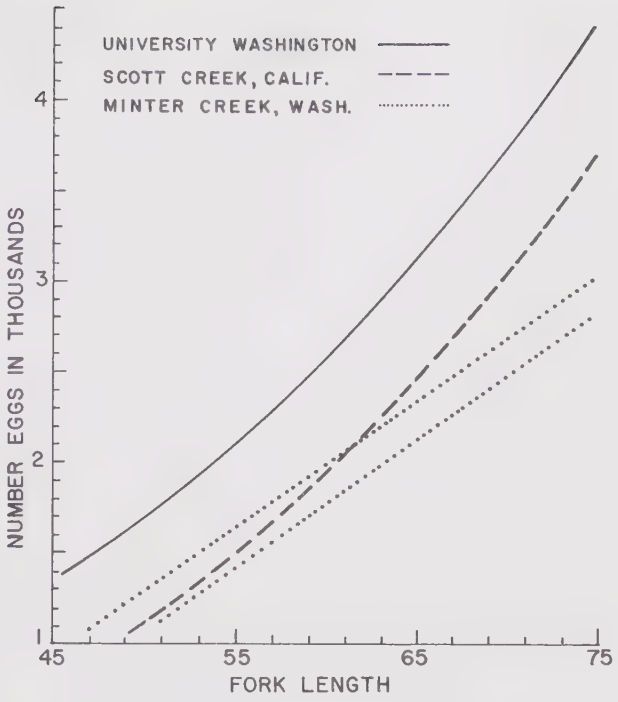

FIGURE 2.-- Length-fecundity relationships for silver salmon from three areas of the Pacific coast of the United States. Standard length of Minter Creek fish was converted to fork length by a factor of 1.1. Standard error of estimate: University of Washington, 155; Minter Creek in 1937, 157; and Minter Creek in 1939, 132.

the number of eggs required to fill a 12-inch trough. The eggs tend to line up with their shorter axes parallel to each other. This results in more eggs in the trough and therefore in a smaller average diameter. Every effort was made to avoid "packing" the eggs when arranging them along the trough. Selection of the sample to be placed in the trough was made immediately after "bumping," which consisted of siphoning all eggs of a lot from its hatchery basket into a rubber pail placed on the hatchery floor. This insured a thorough mixing of the eggs.

Rounsefell (1957) presented no data on egg size as compared to fish length for the silver salmon. In general, in the present study, the smaller fish produced no larger eggs and the larger fish produced no smaller eggs (figure 3). However, the range in size of eggs produced by fish of a given length was considerable, with fish of average length producing eggs of both large and small average size.

Rounsefell also found no data on the relationship between size of egg and number of eggs produced by individual silver salmon. Size of egg and number of eggs for individual females showed little correlation for the University of Washington salmon (figure 4). For the 72-centimeter female producing 5,700 eggs, this large number of eggs was the result of a large volume of eggs and not the result of a small average diameter of the eggs (figure 2).

Change in Fecundity With Progression of Run

Female silver salmon were taken in the traps from late November until mid-February; the majority were recovered from mid-December until early January. These fish were planted as fingerlings at the same time at the University of Washington and were taken from the 1950 brood

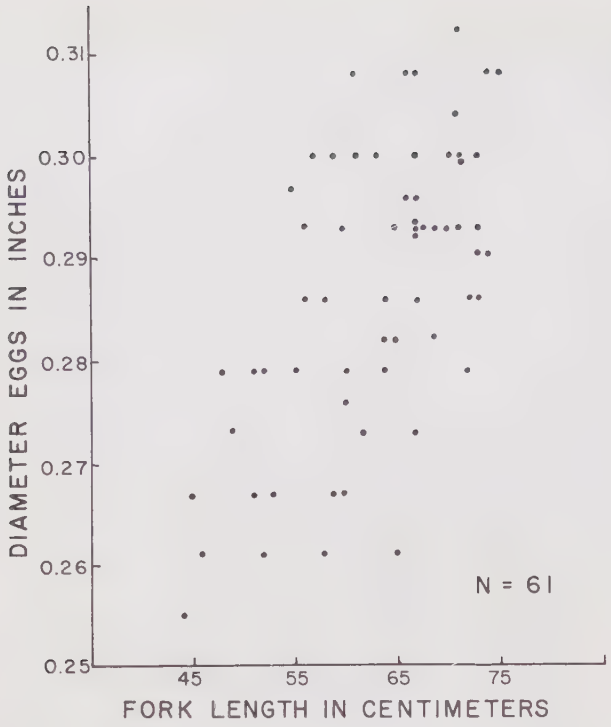

FIGURE 3.--Relationship between average diameter of eggs and length of individual female silver salmon.

year at the Washington Department of Fisheries hatchery on Green River (Soos Creek) (Donaldson and Allen, in press). The run of silver salmon to Green River generally appears at the traps during late November. Most of the silver salmon returning to the University of Washington in 1953 had entered fresh water by early November, as indicated by the return of marked fish from the sport and commercial fisheries in Puget Sound.[4/]

The possibility of change in fecundity with time of arrival was studied by plotting for each fish the deviations from the fecundity relationship shown in figure 1 according to the week of arrival. Graphically there was a slight tendency for early-arriving fish to have a higher average fecundity than fish arriving during the latter part of the run. Statistical analysis showed that the correlation was not significant.

[4/] See footnote 1, page 163.

The data of Salo and Bayliff (1958: figure 28) showed daily fluctuations in average fecundity which were correlated with changes in average length. Their data also showed a slight tendency for early-arriving fish to have a higher average fecundity for fish of the same length, but statistical analysis probably would show that the trend was not significant. This phenomenon should be investigated further.

Average Fecundity of Silver Salmon Along the Pacific Coast

The average number of eggs for 63 silver salmon females of 63-centimeter mean fork length from the 1950 brood year returning to the University of Washington in 1953 was about 3,100. The range in the number of eggs produced was from 1,440 for a female 44 centimeters in length to 5,700 for a female 2 centimeters in length.

A comparison of the average fecundity of populations of silver salmon from the Pacific coast of North America is given in table 2. These data are essentially the same as those listed in Rounsefell (1957: appendix, table 1) but include data from the present study and from Salo and Bayliff (1958).

At Minter Creek, the average fecundity for the years 1937 through 1954 was obtained by dividing the number of eggs taken by the number of females spawned each year. Salo and Bayliff (1958: 40) wrote: "This estimated fecundity was from 25 to 100 eggs lower than the actual fecundity." This error is due to eggs which remain in the female's body after spawning as a result of the procedures involved in handling and spawning large numbers of fish. As the average calculated fecundity for each year is influenced by hatchery operations, the data for the years 1951 through 1954 were considered most typical for the station. An average fecundity of 2,500 eggs for these 4 years could not be related to an average length (table 2).

The average fecundity of the 1950 brood year at the University of Washington is one of the highest figures reported in the literature (table 2). An average fecundity of 3,300 was reported at Minter Creek in

TABLE 2.--Average fecundity of silver salmon of the Pacific coast of North America

Average number of eggs	Average fork length (cm.)	Size of sample	Area	Reference
3,100	[1]/63	63	University of Washington	Present study
3,002	[1]/69	21	Namu Canner, B. C.	Foerster and Pritchard (1936)
3,152	[1]/64	48	Fraser River, B. C.	Do.
2,320	--	--	Cowichan River, B. C.	Neave (1948)
2,313	--	--	Port John, B. C.	Do.
2,500	65	65	Scott Creek, Calif.	Shapovalov and Taft (1954)
2,310	[2]/--	--	Nile Creek, B. C.	Wickett (1951)
2,482	[2]/60	749	Minter Creek, Wash.	E. O. Salo.[3]
2,617	[2]/64	840	Do.	Do.
2,500	--	1,120	Do.	Salo and Bayliff (1958)

[1]/Total length.

[2]/Standard length (same data given in Salo and Bayliff (1958) but without inclusion of the average length of the fish).

[3]/Salo, E. O. Silver salmon survival studies at Minter Creek, Washington. Ph.D. thesis, 1955. University of Washington. Obtainable on microfilm from Dissertation Abstracts at University of Michigan, Ann Arbor.

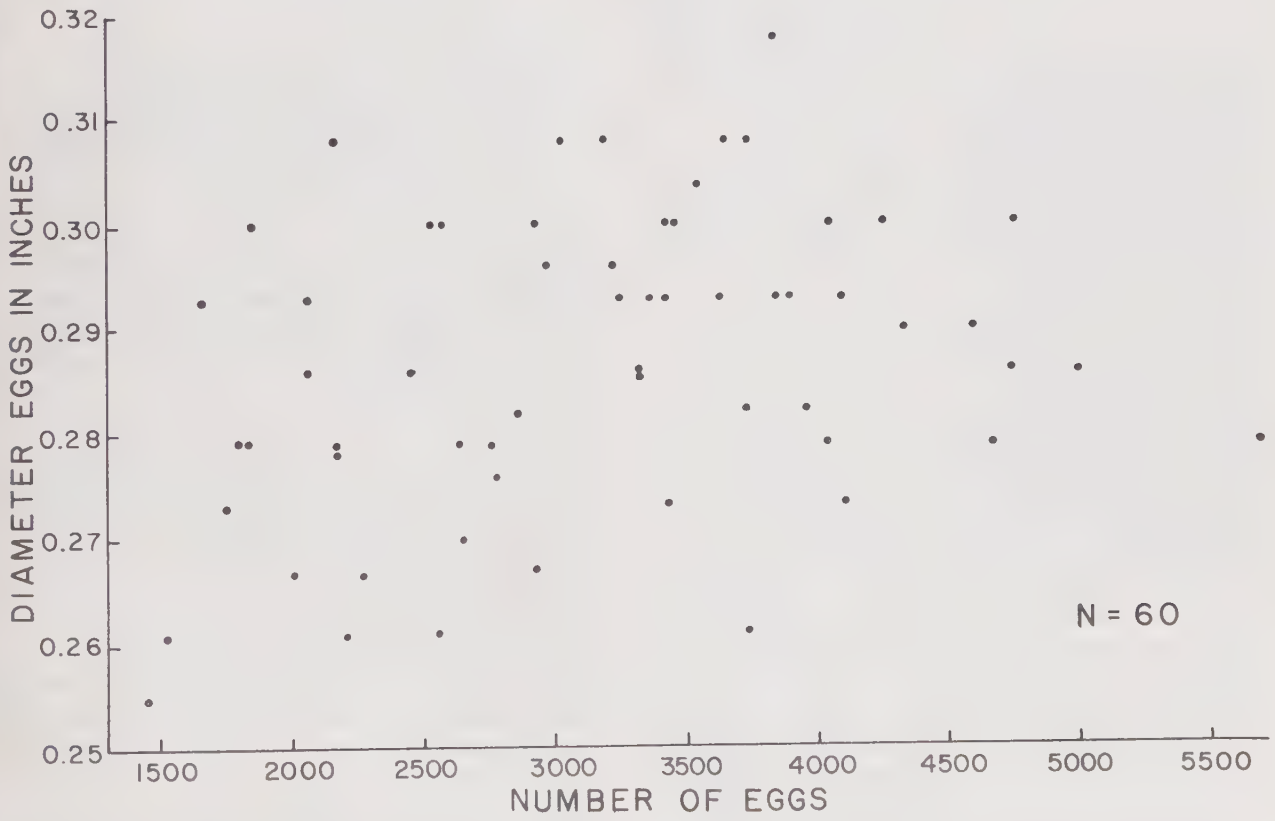

FIGURE 4.--Relationship of average diameter of eggs and number of eggs from individual female silver salmon.

1940; however, only 60 females were spawned artificially from a run which included 1,575 females. There was very likely selection of larger fish.

There was a large difference in the average fecundity of the 1950 brood-year silver salmon returning to the University of Washington (3,100) and to Minter Creek, Washington (2,343 --Salo and Bayliff 1958: table 4). Adjusting to the maximum for the known source of error involved in obtaining these figures (10 percent overestimation for use of Von Bayer technique, and 100 eggs left in the carcass of Minter Creek females), there is still a sizable difference of 2,800 eggs as compared with 2,443. It is recognized among hatchery personnel that the average fecundity of silver salmon is greater at the Green River (Soos Creek) hatchery than at Minter Creek. This is a function of a larger average size of the Green River stock, which tend to migrate "outside" Puget Sound to the Pacific Ocean--in contrast to the Minter Creek silver salmon, which tend to remain more "inside" Puget Sound or in closely adjoining areas (Pressey 1953). The 1950 brood year at the University of Washington was distinctly an "outside" stock as compared with the 1950 brood year at Minter Creek, which remained predominantly "inside" Puget Sound.[5/]

Remarks

It would appear hazardous to estimate the total egg deposition for a stock of silver salmon in a particular stream, using average fecundity data as reported in the literature. We may assume that there is a range in average fecundity for a particular stock which is determined genetically. However, there is also the possibility of variation in fecundity because of environmental conditions encountered in the ocean feeding grounds (Vladykov 1956). It is evident that the data presented will have to be interpreted in the light of variations to be expected in the fecundity between different stocks, between different years for the same stock, and as the result of differences in techniques of egg enumeration.

[5/] See footnote 1, page 163.

Acknowledgments

Appreciation is expressed to the University of Washington School of Fisheries for the opportunity to study the 1953-54 run of salmon. The State of Washington Department of Fisheries collaborated with the School of Fisheries by furnishing the fish for the original experiment that made the present study possible. Dr. E. O. Salo made invaluable personal comments.

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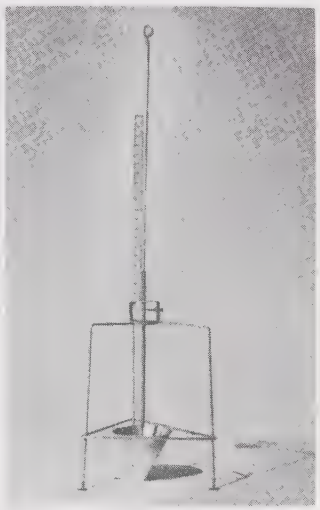
A SIMPLE FOOD-CONSISTENCY TESTER

In Sweden large salmon-rearing stations that maintain many rearing units or troughs have adopted various types of automatic feeding apparatus in order to reduce labor costs. The food is given to the parr in rations, and experience has shown that the parr take the food more readily when it is floating in the water or on the surface than when it is rolling on the bottom. The desired "behavior of the food" leads to certain requirements as to consistency, content of air bubbles, and related features.

At large stations the food is seldom prepared by experienced fish-culturists, men who are able to estimate the proper consistency. Thus, an objective method of measuring the consistency is of value.

Geotechnicians and ecologists have used a fall-cone technique in their studies of the consistency of soils and bottom deposits. Shown here is a modification of the fall-cone technique. This involves use of two fall heights (5 and 10 centimeters). The consistency of the food is measured in terms of the depth (millimeters) to which the point of the cone penetrates the food mass. The higher the value the looser the food. The 3-foot height of the device permits it to be kept in the right position in relation to the food surface.



(Photo courtesy of H. Peterson)

The experienced fish-culturist first finds the most desirable consistency for the different food mixtures and the corresponding value for the food tester. The personnel who prepare the foods are then instructed to maintain a consistency known as tested value.

The tests can be made in the food mixer or in the food containers.

--- ARNE LINDROTH, Bergeforsens Hydroelectric Company, Sorberge, Sweden.

FOOD HABITS OF THE NORTHERN RIVER CARPSUCKER IN MISSOURI

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Columbia, Missouri

FOOD PREFERENCES OF INDIVIDUAL GROUPS OF ORGANISMS have been determined through careful study of consumed material as well as examination of the morphology of the feeding apparatus. The carpsucker, in this respect, has been described as having no definite food preferences but consuming mud, debris, and other unidentifiable morsels. The feeding habits of this species have been likened to a vacuum cleaner, as the carpsucker feeds at the bottom and takes everything which may be sucked up.

In the past, many fishery biologists have not made use of the compound microscope and slide preparations for food-determination studies. The binocular dissecting microscope has been the most popular instrument, probably because of speed of examination, ease of procedure, and limited budgets. The principal limitation of this method is the low magnification achieved, which results in substantial reduction in the range of identifiable material. Organisms in the size range of most planktonic forms would indeed be difficult, if not impossible, to identify with less than 100-diameter magnification. It is understandable, then, that many of the previous reports have shown that the greatest quantity of the carpsucker's food is "unidentifiable material."

One aim of this paper is to contribute some information as to the specific food preferences of the carpsucker and, consequently, to take one step in defining the ecology of this species. Another aim of this paper is to encourage future investigators to examine all avenues of approach in determining the ecology of a species and, with regard to food-habit studies, to exhaust all identification procedures before labeling material "unidentifiable."

Food-habit studies of the northern river carpsucker, Carpiodes carpio carpio (Rafinesque), have been neglected by fishery research workers. Yet, in order to describe completely the ecology of the species, a food-habit study is of prime importance.

Forbes and Richardson (1920) gave a brief account of the food habits of the carpsucker and stated that the carpsucker was a "filthy feeder, swallowing a greater quantity of mud than the nearly related buffalo fishes." One cannot deduce the food composition from this description, save for the intimation that the carpsucker is a benthic feeder. Buck and Cross (1952) stated that the food of the carpsucker from the Canton Reservoir, Oklahoma, was principally unidentifiable material gleaned from the bottom ooze. Mr. Harry M. Harrison, of the Iowa Conservation Commission, was quoted (1956) by Harlan and Speaker as stating that the food of the carpsucker was composed of insects and larvae (2 percent), plant material (12 percent), and unidentifiable material (86 percent).

Contribution of the Missouri Cooperative Wildlife Research Unit, the U. S. Fish and Wildlife Service, Missouri Conservation Commission, and University of Missouri cooperating.

For the present study, 100 northern river carpsuckers were taken from the Lake of the Ozarks, Missouri. Collections were made during an entire year, from June 1953 through June 1954. The total lengths of these fish ranged from 40 to 450 millimeters.

The carpsucker has a relatively simple digestive tract. There is no external morphological differentiation of the intestine into a definable stomach, nor are pyloric caeca present. The esophagus empties into a small globular organ which Berner (1948) termed the "stomach." The organ is heavily muscularized and, in the present study, was found to contain sand grains as well as a copious discharge from the bile gland. In all of the examinations made, there was never any food in this organ. It appeared likely, however, that the source of the sand grains was the testa of the protozoan, Difflugia, which had been ground up in this area. For this reason and because of the location and appearance of this organ, I propose to call this area the "gizzard."

The intestine, then, extends from the gizzard and proceeds directly caudad. Just at the posterior end of the abdominal cavity, the intestine turns sharply forward and, adpressing the first section, returns to a point below the posterior margin of the gizzard. I refer to the former turn as the "first posterior loop." The intestine then turns caudad once more and forms a series of spirals before terminating at the anus.

The food-habit study was composed of two steps. The first was a gross examination of the intestinal contents under a binocular microscope at a magnification of 3X. The data obtained by this means are reported in later paragraphs as macroscopic findings. The second step was a detailed examination of the intestinal contents under a compound microscope at a magnification of 100X, which provided data referred to hereafter as microscopic findings.

The contents of a section of the intestine, from the gizzard to the first posterior loop, were emptied into a petri dish. A macroscopic examination of these intestinal contents was made, and the major groups of organisms and their numbers were recorded.

The contents were then diluted with 1 cubic centimeter of water and mixed thoroughly. Two drops of the resulting suspension were placed in a depression slide and examined under a magnification of 100X. Three separate samples of this suspension were examined in order to get as random a sample as possible. The major groups of organisms and relative abundance were recorded for each sample.

At a magnification of 3X, only the larger forms of bottom organisms and plant material could be identified; the rest of the material, which constituted 60 to 100 percent by volume of intestinal contents, was mudlike in appearance and in consistency. Upon examination at a magnification of 100X, however, most of the mudlike intestinal contents were found to be identifiable micro-organisms which were, in the main, members of the plankton group.

Gross analysis of the two steps in the procedure showed that gut contents identifiable under 3X magnification were present in only 42 percent of the carpsuckers examined, whereas 100 percent of the examinations under 100X magnification showed considerable quantities of identifiable micro-organisms. Hence, it was evident that the carpsuckers made comparatively little use of the macro-organisms. Of these macro-organisms, 26 percent were chironomids; 23 percent were unidentifiable plant material, which included twigs, leaves, and stems of Polygonum, Dianthera, and other species; and 14 percent were oligochaetes. Incidences of these and other findings are shown in figure 1.

The micro-organisms were found to have been utilized by all the carpsuckers examined in the present study. The major food items were: desmids, 63 percent; cladocerans, 55 percent; filamentous algae, 52 percent; and diatoms, 48 percent. Other findings are presented in figure 2.

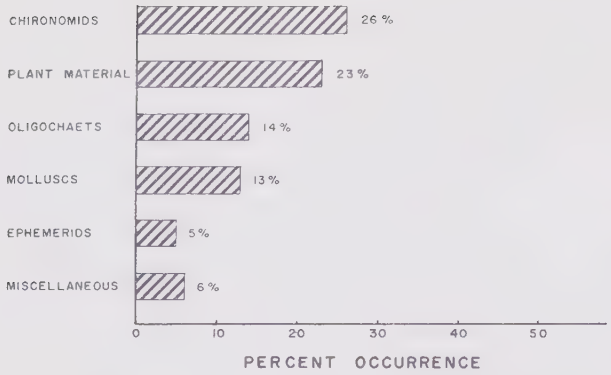

FIGURE 1.--Percentage occurrence of food organisms found in a macroscopic examination of the intestinal contents of the northern river carpsucker. (3X)

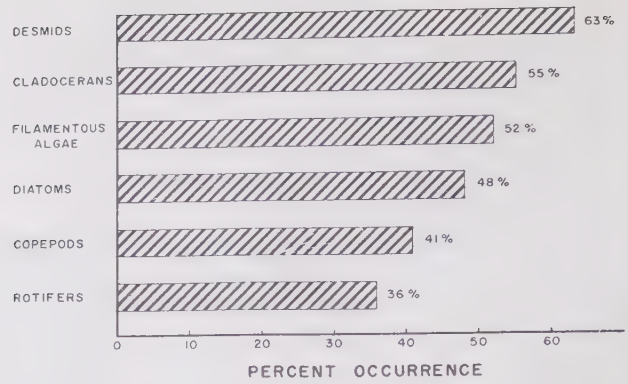

FIGURE 2.- Percentage occurrence of food organisms found in a microscopic examination of the intestinal contents of the northern river carpsucker. (100X)

The frequency of occurrence[1] of food items according to size of the fish (see table) showed no break in the occurrence of microscopic food material. There was an absence of the larger benthic forms in the small fish which may be attributed to the size of the food item and the size of the digestive tract.

It has often been assumed that micro-organisms in the carpsucker's diet represented material which was already dead at the time of its consumption. On this point, the following observations seem pertinent. All of the material recovered from the samples was easily identified. It was apparent that maceration had not taken place. Throughout the samples that were taken in the spring and summer, many of the copepods had eggs still suspended from the cephalothorax, the ovisac intact. Cladocerans were found holding eggs in the brood pouch. The cellular contents of the filamentous algae were clearly defined--including the nucleus and chloroplasts in the filamentous green algae. Reproduction was evident, as conjugating forms and zygotes were seen. From this evidence it appears possible to assume that the micro-organisms were alive at the time they were consumed.

Sand grains were found in considerable amounts. With the large numbers of Difflugia present in some of the samples, it seemed probable that the sand grains were derived, for the most part, from the testae of these protozoans. Eight thrips (Thysanoptera) were found in three of the fish examined. These insects were almost perfectly preserved, and it was thought most probable that they had been taken alive from or close to the surface of the water.[2]

The feeding habits of the carpsucker are unknown, and this becomes an important question when the large amount of plankton in its diet is considered. From the structure of the gill rakers and the subterminal position of the mouth, it is obvious that the carpsucker is not equipped to gather plankton as is a true plankton feeder. This fact, coupled with the large amount of filamentous algae that the carpsucker eats, leads me to believe that this fish browses submerged rocks which are covered with algae. Associated with these algae are large numbers of plankton, and

[1] By frequency of occurrence is meant the number of fish found with the food material, regardless of quantity. Percent occurrence is the frequency of occurrence expressed as a percentage of the entire collection.

[2] Dr. Lewis J. Stannard of the Illinois State Natural History Survey identified the thrips as Holothrips sp. and Limnothrips cerealium.

FREQUENCY OF OCCURRENCE OF FOOD ORGANISMS OF CARPSUCKERS BY LENGTH INTERVALS

Length interval (mm.)	Number of fish	Macroscopic				Microscopic	
		Insects	Oligochaetes	Plants	Molluscs	Flora	Fauna
40- 49	2	--	--	--	--	2	2
50- 59	4	--	--	--	--	4	4
60- 69	6	3	--	--	--	6	6
70- 79	0	--	--	--	--	--	--
80- 89	6	--	--	--	--	5	3
90- 99	5	--	--	--	--	5	4
100-109	7	--	--	--	--	7	4
110-119	4	--	--	--	--	4	0
120-129	3	1	--	--	--	3	1
130-139	2	--	--	--	--	1	2
260-269	1	--	--	--	1	1	1
270-279	1	1	--	1	1	1	1
330-339	1	1	1	--	1	1	1
340-349	1	--	--	--	--	1	1
350-359	3	2	1	1	1	2	3
360-369	4	2	1	3	1	3	4
370-379	8	3	3	2	--	5	4
380-389	8	3	1	1	--	5	7
390-399	6	4	1	3	1	5	5
400-409	10	5	1	4	--	7	7
410-419	8	6	2	3	3	7	7
420-429	5	2	2	2	2	3	3
430-439	4	3	--	2	2	4	3
440-449	0	--	--	--	--	--	--
450-459	1	1	1	1	--	1	1
Totals	100	37	14	23	13	83	74

these are consumed by the carpsucker in the course of gathering the algae and other plant material.

From the statements of other investigators, it might have been assumed that the carpsucker is an obligatory bottom feeder. My findings make it apparent that the carpsucker in the Lake of the Ozarks is not entirely a benthic feeder.

Summary

1. One hundred northern river carpsuckers, Carpiodes carpio carpio (Rafinesque), taken from Lake of the Ozarks, Missouri, were examined and their gut contents analyzed.

2. The samples were examined first under a dissecting microscope at 3 diameters and then under a compound microscope at 100 diameters.

3. Observations showed that material which had heretofore been termed "unidentifiable" was, in reality, recognizable plankton material.

4. The following conclusions were reached:

(a) The carpsucker is not a mud feeder.

(b) The carpsucker is not a scavenger on waste and decaying organic matter.

(c) The carpsucker is probably a browser, feeding near the bottom and utilizing the periphyton associated with submerged rocks and debris.

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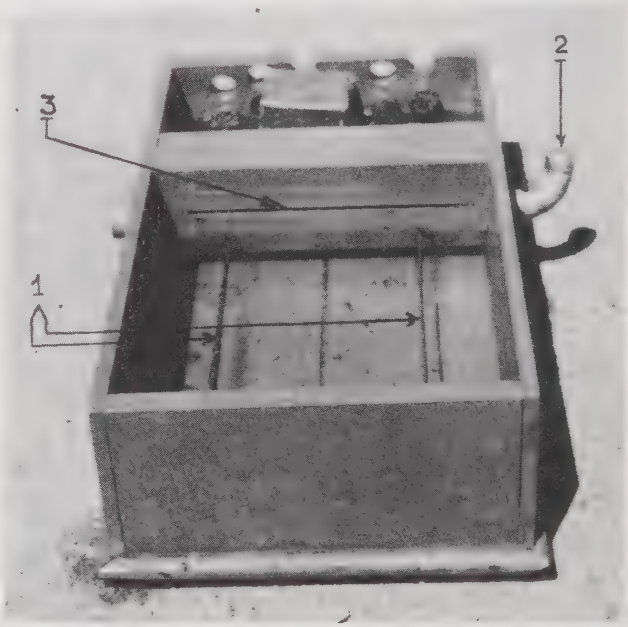
INCUBATORS USED IN BRAZIL

Because it is necessary to plant and stock drought areas in Brazil, the Servico de Piscicultura do D. N. O. C. S. has made many investigations to determine the apparatus best suited for the rearing of fish in the early stages of their development. Dr. Antonio Carlos Estevao de Oliveira (biologist) and Oceano Atlantico Linhares (technician) are credited with devising the incubators now employed in the hatcheries of the Servico.

The eggs of all the native and acclimated fishes used by the Servico are of two types: adhesive eggs with density superior to that of water, and separate eggs with density slightly greater than that of water.

Adhesive eggs, collected by placing bricks in the spawning tanks of these species, are hatched in an open, waterproof wood box that is divided into two sections. The photograph shows the wire supports (1) on which the bricks with eggs are placed; the pipe (2) through which water is brought into the larger section; and the slit (3) through which water passes into the smaller section, which contains a pressure chamber.



Eggs of the second type are incubated in a glass or brassplate cylinder that is open above and rounded at the base. In this base is a tapered metal chamber that has a small, eccentric hole at bottom and many millimeter-sized holes on top. The water forced through this chamber carries the eggs upward almost to the level of the overflow. The latter is a metal tube extending from a hole at the center of the cylinder base almost to the top of the cylinder. A brasswire screen supported by copper wire keeps the eggs from falling into the overflow.

--- OSMAR FONTENELE, Servico de Piscicultura do Departamento Nacional de Obras Contra as Secas, Fortaleza, Brazil.

TRANSPORTING SMALL LIVE TROUT IN SEALED POLYETHYLENE BOTTLES

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Bureau of Sport Fisheries and Wildlife
Creede, Colorado

TRANSPORTING LIVE FISH has long been a problem to fish-culturists. This article is an account of a practical method for transporting small live trout fingerlings. This method has been in use at the U. S. Fish-Cultural Station at Creede for the past 2 years. Experiments were begun with a single unit. Twenty-four units are now in use, and their convenience has practically eliminated the distribution of fingerlings with heavy cans or pails.

The basic principle described is not original, but the adaptations developed for use with trout are believed to be new. Similar units are being tested by the Colorado Game and Fish Department for stocking by airplane. Detailed experiments have been and are being carried on with warm-water fish by those equipped to do so (Nemoto 1957). Considerable work needs to be done to set up tolerance tables for ready reference for various species, sizes, and numbers of fish in relation to water temperatures, oxygen-water charge ratios, sedative drugs, metabolic-waste neutralizing agents, and time factors.

The Problem

Trout production at the Creede station consists mainly of fingerlings which are used to stock lakes and headwater streams in the high country of Colorado. Tourist and fishing expeditions into the surrounding National Forests play an important part in the economy of the region. Well-stocked fishing waters are an important contribution to this popular type of recreation. Although jeeps and airplanes are useful in stocking fish at some locations, most plants must still be made with pack animals. Transportation of large numbers of small trout over periods of 2 hours to 2 days, by pack outfits, has been rather strenuous work during past seasons.

Old Stocking Equipment: Cans

At the hatchery small trout were placed in 10-gallon pack cans or milk cans containing about 8 gallons of water. These were iced, wrapped in wet burlap, loaded on a pickup truck and rushed to a predetermined spot for transfer to pack animals. The pack-string operator rounded up and saddled 2 to 12 horses or mules, loaded them onto a larger truck, and drove to the meeting point. Horses and cans were then unloaded, the cans wrapped in wet burlap and lashed securely to the pack animals. After these time-consuming steps, they were ready to hit the trail. Not infrequently mules or horses objected to having ice water spilled on their backs from bulky, clanking cans and acted accordingly. The result: confusion, delay, and lost fish. Also, a horse could carry only 2 cans (each weighing about 90 pounds and containing 1 to 1.5 pounds of fish at 200 to 1,200 per pound).

New Stocking Equipment: Covered Polyethylene Bottles

The system now in use at the Creede station eliminates all the heavy labor,

Polyethylene-bottle distribution units, showing the water-poundage scale inscribed on outside and the funnel.

Insulated carrying bags, showing the flap closed (center) and the extra protective cover-all plastic bag (right).

reduces the number of men and pack animals required, reduces the number of lost fish, and saves time. Lightweight polyethylene bottles that contain fish and a small amount of water and oxygen are now slipped into insulated covers and packed on the animals.

The ordinary industrial-type polyethylene bottle, with screw-top opening (1-3/8 inches) and 2-gallon capacity, is used. A piece of 1/4-inch rigid copper or aluminum tubing, 15 inches long, is inserted through the screw cap and extended to within approximately 2 inches of the bottom of the bottle. A piece of fine-mesh hardware cloth is fastened over the bottom end. Enough of the tube projects through the top to allow for threading and screwing on an ordinary tire valve cap. A second short piece of tubing is inserted so that it just goes through the top. The projecting end of this short tube is threaded inside and out for insertion of a tire valve with a cap. These tubes must be sealed tightly into the bottle top to prevent loss of oxygen under several pounds of pressure.

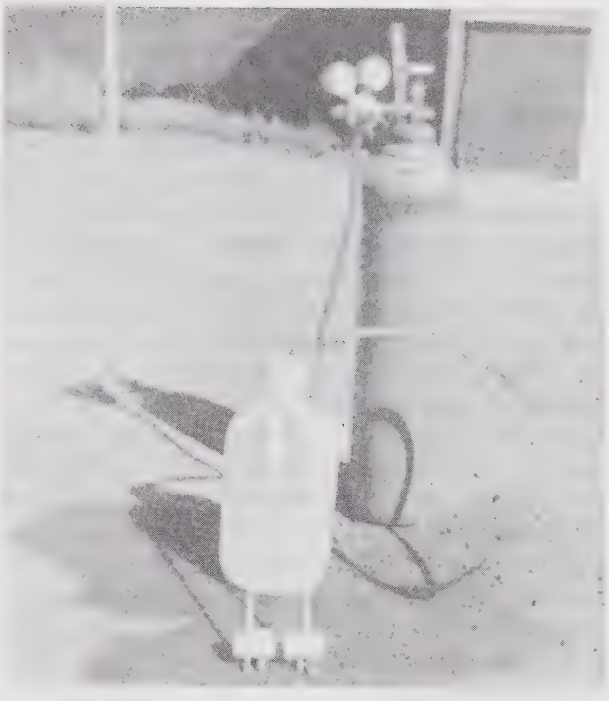
A lightweight, insulated carrying cover has been devised for the bottle. For this cover, fiberglass has proved most desirable because of its lack of bulk, light weight, resistance to mold and moth, and readily adaptable form. The baglike cover is made of 2 thicknesses of 1-pound density fiberglass batting (1 inch thick) set between 2 thicknesses of Nylo-Tarp (high-grade wear-resistant neoprene compounds combined with DuPont nylon). These materials are cut over a pattern to make a well-fitting slip-on bag with sealed seams of nylon thread. Eyelets and drawstring make possible quick, tight closing of the bag. A flap, slightly smaller than the inside circumference of the bag, is sewn inside at a point convenient for fitting over the bottle top. This flap protects the protruding valve stems and also provides some additional insulation seal.

Loading and Charging the Bottle

Water is poured through a funnel into the bottle until it is about half full. Trout

fingerlings (1 to 1-1/2 pounds, depending on the time and distance involved) are added. At this point crushed ice, small ice cubes, or 1-grain pellets of sodium amytal are added if desired. Then the bottle is filled with water. Next the large screw top is tightened securely with hand pressure only. (A bit of heavy carbolated vaseline on the threads sometimes helps here.)

The actual oxygen charge is introduced from an industrial-type compression cylinder, through a hose equipped with a standard air-injection valve as used to fill tires. Pressure is controlled by a regular industrial-type set of gauges at the cylinder outlet. Injection is made through the short tube containing the valve gut. This forcing of oxygen into the filled bottle causes the displaced water to spurt through the end of the long tube like a miniature fountain. The screening over the end prevents the small fish from being forced against or becoming lodged in the long ejection tube. Oxygen replaces the water in the bottle to any desired level as calibrated in pounds on a scale inscribed on the outside of the bottle. When the desired oxygen-water ratio is reached, the valve cap on the long ejection tube is quickly screwed on. The injection of oxygen can be continued a second or two longer, causing a slight pressure to build within the bottle. (Experience has shown that this pressure is of questionable value and should be used with caution. Accurate gauging of this internal pressure has not been possible with the equipment at the



Bottle-top tube and valve arrangement for oxygen charge.

COMPARISON OF POLYETHYLENE BOTTLES AND PACK-TYPE OR 10-GALLON CANS

	Polyethylene bottle	Pack-Type or 10-gallon can
Capacity	2 gal.	10 gal.
Weight when empty	2-1/4 lb.	21 lb.
Weight of		
insulated cover	1 lb. 6 oz.	----------
burlap wrap, wet	----------	10 to 15 lb.
Weight when loaded	8 to 12 lb.	90 to 100 lb.
Ice used	1 to 3 lb.	10 to 25 lb.
Over-all dimensions	20 x 8 x 8 in.	26 x 18 x 10 in.
Capacity in fish (normal 4- to 8-hour trip)	1 to 1-1/2 lb.	1 to 1-1/2 lb.
Number carried per horse	6 to 10	2
Number carried per man		
on back pack-board	3	----------
for any distance	----------	0

NOTE: All figures above are based on average loads and preparations. Attempts to compensate for time and weather on long trips often make these figures vary accordingly.

Creede station.) When the injection hose has been removed, the valve cap is tightly screwed in place. Charging should be done in this sequence for convenience and to prevent waste of compressed oxygen.

A bottle so loaded and charged contains fish and one-half or more of its volume of oxygen and one-half or less of water as desired. Under most conditions, 5 to 7 pounds of water per pound of fingerlings seemed about the best ratio. Because undue pressure injured the small fish and gauging was not accurate, no particular effort was made to create internal pressure; the chief aim was just to replace water with oxygen to the desired level and secure a tight seal. Seals were always tested by placing the bottle under water after a charge. If a check of the screw-top and valve caps revealed no leaks, excess water was wiped off and the bottle was slipped into its insulated cover--ready for transport.

In addition, a thin transparent bag secured with a rubber band was often used to help protect the outside surface of the insulated bag from mud and dirt. This cover-all (approximately 24 by 12 by 8 inches) costs little for the extra protection afforded and can be used over and over again.

With a little experience, one or two men can load and charge a number of such bottles in a short time. Three bottles can be laid horizontally in an ordinary canvas pack pannier and covered with wet burlap, ice, or packages of some refrigerant. These measures aid in keeping the entire pack cool. Additional bottles can also be tied to the pack where convenient or to a rider's saddle. Men can strap several to a back pack board and carry them easily to their favorite fishing spots. One precaution worthy of note in all packing is to keep the bottles in a horizontal position. This gives the fish more freedom of movement, and the sloshing provides a better mixture of the oxygen and water.

GUIDE FOR TRANSPORTING SMALL TROUT VIA SEALED-BOTTLE METHOD

[Water temperature when loaded, 45° F.]

Fish per bottle (lb.)	Water per bottle (lb.)	Safe time limit for fish: 500 to pound (hr.)	Safe time limit for fish: 1,000 to pound (hr.)
0.75	8	8 -10	10 -12
.75	7	10 -12	12 -14
.75	6	12 -14	13 -15
.75	5	14 -15	15 -16
.75	4	13 -14	14 -15
.75	3	12 -13	13 -14
1.00	8	5 - 6	6 - 7
1.00	7	6 - 7	7 - 8
1.00	6	7 - 8	7 - 8
1.00	5	8 - 9	8 - 9
1.00	4	8 - 9	8 - 9
1.00	3	6 - 7	7 - 8
1.25	8	4 - 5	4 - 5
1.25	7	4 - 5	5 - 6
1.25	6	5 - 6	5 - 6
1.25	5	5 - 6	6 - 7
1.25	4	4 - 5	5 - 6
1.25	3	3 - 4	4 - 5
1.50	8	2 - 3	3 - 4
1.50	7	2.5- 3.5	3 - 4
1.50	6	3 - 4	4 - 5
1.50	5	3.5- 4.5	4.5- 5.5
1.50	4	3 - 4	4 - 5
1.50	3	2 - 3	3 - 4

NOTE: The general condition of the fish used in any such tests or for actual transportation is important. This guide was compiled with healthy fingerlings from wild stock that had never been treated for any form of disease. Fish are always starved at least 24 hours before being loaded for actual trips. The same was done for these hatchery tests. No added drugs, chemicals, or other agents were used in compiling the figures. This is only a rough preliminary guide. Varying water conditions at other hatcheries may make it necessary for them to compute their own guides.

Need for Additional Experiments

Much more experimental work should be done to determine the limitations of this method of transporting small live trout.

Trial and error on about 25 pack trips provided some of the information that is now being used as a guide. Pack-string operators were asked to prepare reports,

but some of these were incomplete and inaccurate.

In the hatchery troughs nearly uniform water and air temperatures made possible better controlled tests. Rainbow fingerlings, about 500 to the pound, were used most extensively for this work. Various numbers were loaded into bottles in the manner already described. The bottles were sealed and placed directly in troughs of running water in the unheated hatchery room. The water had an average constant temperature of about 45°; room temperature did not get above 55°. Bottles were rotated and shaken at least every 30 minutes during tests to simulate, to a limited degree, the movements of transportation. When fish in a bottle began to show marked distress, they were released into an empty trough. Here they were observed at least 3 days for symptoms of ill effects or delayed reactions. These observations revealed no particular trouble that could be attributed directly to retention in the bottle. If pressure had been used, there was usually some mortality. Some fish became sick if they were confined a bit too long, but fresh water usually revived them after a short time. Other fingerlings gave indications of what might be described as an "oxygen drunk" and behaved erratically for a time. Usually these fish also recovered rapidly. When fish recovered, no prolonged aftereffects could be noted by such casual observation. Blood counts or detailed studies could not be made at this station. In the few tests with other species, brook trout seemed to stand confinements for the longest periods, whereas brown trout seemed able to stand the least. This may have been due to the particular strain of fingerlings used. Of course, past or present occurrence of disease--especially disease of a respiratory nature--would affect the results of carefully conducted research.

Preparations for stocking trips from the Creede station are made in accordance with the guide (see preceding page) prepared from data obtained in these preliminary hatchery tests, although field conditions likely to be encountered are always taken into consideration.

Conclusions

Field trials and hatchery experiments over the past 2 years have led to the following conclusions:

1. The polyethylene bottle has many advantages over other types of containers under experiment.

2. More detailed experiments, made by trained personnel using laboratory equipment under controlled conditions, are needed. This work should include studies of the use of chemicals and drugs, pressure limits, and larger sealed units.

3. Comprehensive but easily interpreted reference tables are needed. They should include temperature, oxygen-water ratio, species, number, size, and time limitations.

4. The initial cost and upkeep of the polyethylene-bottle unit compare favorably with other means now used for transporting small numbers of fingerlings.

Acknowledgments

Mr. Carl Burnham and his staff of the Burnham Products Company, Inc., worked with the author to provide manufacturing facilities for the units as now perfected. Mr. T. E. French, Superintendent of the U. S. Fish-Cultural Station at Leadville, Colorado, assisted with information based on his unpublished experiments with trout fingerlings in oxygen-inflated plastic bags. Local pack-string operators and sportsmen volunteered their equipment, conveyances, effort, and time to work on this project.

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A SIMPLE TECHNIQUE USED FOR LABORATORY HATCHING AND REARING OF FISH

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A SIMPLE NONFLOW PROCEDURE for the hatching of salmonid eggs, a procedure which could facilitate studies on the physiology and nutrition of developing salmonid fish, has been devised. A major obstacle in pursuing such studies is the necessity of conducting the research near a fish hatchery--rarely located conveniently. Standard hatchery procedures require a large supply of fresh unchlorinated water that is not readily available to most urban research laboratories. The use of running water makes the control or experimental manipulation of physical and chemical conditions difficult and expensive.

The procedure devised is based on the balanced-aquarium principle; i.e., the use of plants to consume the nitrogenous waste and carbon dioxide produced by the animals and to supply, in turn, the needed oxygen. Theoretically, any aquatic photosynthetic plant will fulfill these requirements. It is possible, however, that some plants might produce substances harmful to the animals. Some blue-green algae and dinoflagellates are known to produce substances toxic to vertebrate or invertebrate animals (Brian 1957).

To determine the possibility of rearing salmonid eggs in a nonflow system of this nature, the following experiments were conducted at the Ketchican fish hatchery of the Alaska Department of Fish and Game. Three 40-watt cool, white, fluorescent light tubes were suspended 75 centimeters above a table top and 25 centimeters apart. Light intensity on the table top was about 150 foot-candles. The air temperature in the hatchery during the period of experiments was between 6° and 11° C. Rectangular pyrex dishes (19 by 8 by 6 centimeters) were filled with water from the head trough in the hatchery, and a dense suspension of unicellular algae was added. The algal suspension was obtained by enriching lake water with nitrate (100 mg%) and phosphate (20 mg%) and keeping the enriched water under continuous illumination. The predominant alga in the suspension was a Chlorella. Green flagellates were also present in considerable number.

In the first of these experiments, 260 eyed sockeye salmon eggs were spread in a single layer on the bottom of the dish. The dish was placed on the illuminated table top and kept there undisturbed under continuous illumination. Dead eggs were removed as they were detected, and the algal suspension was diluted when it became too dense. No careful control of the algal density was attempted. The density of the suspension was such as to make the eggs on the bottom of the dish readily visible when observed from above through the 6-centimeter suspension. The eggs hatched about 40 days after the beginning of the experiment; the fry appeared normal and healthy. After several days the fry were removed to the standard hatchery trough. In all, 242 live fry were removed from the dish.

In a second experiment, 350 green silver salmon eggs were similarly treated. These developed normally and hatched after about 2 months. During this period

water was added occasionally to compensate for evaporation. Growth of the algae necessitated syphoning off some of the suspension and adding water at intervals. The growth of the algae was not uniform, and a sharp rise in rate of growth was noticed with the start of the hatching. This was probably correlated with the increased excretion of nitrogenous substances at this time (Smith 1957: 346). The eggshells were removed, and the fry were left to continue development in the algal suspension. The fry developed normally and were kept under these conditions until they reached the swimming-up stage. At this stage they were placed in the hatchery troughs. Total mortality of eggs and fry in this dish during the experiment (3 months) included 60 individuals.

In order to evaluate the relative merit of different plants, similar experiments with both eyed sockeye and green silver salmon eggs, using several plants, were conducted. For the purpose of the present study, the plants most readily available to the fish-culturist were used.

The plants tried were: (a) Strands of Chara, (b) green algae mat on small pebbles, (c) moss attached to flat rocks, (d) strands of spikerush. These plants were collected from a creek and lake bed within walking distance of the hatchery. A water dish with no added plants was also used as a control.

In dishes that contained pebbles or rocks, the eggs were not evenly distributed. Clusters of eggs which fell in crevices or between the rocks soon died. On flat surfaces, the eggs fared much better. In the dishes with strands of Chara or spikerush, mortality was high. In the controls, the green silver salmon eggs were all dead after less than 2 weeks. Among the eyed sockeye eggs, several were still alive and hatched 40 days after the start of the experiment. This can be attributed to the growth of naturally present planktonic algae, which, by the end of 40 days, was quite noticeable.

Wolf (1957), working on rainbow trout eggs in a closed-system incubation experiment, with no illumination, observed 100 percent mortality, even when utilizing aeration and circulation of water through charcoal. He concluded that the accumulation of nitrogenous wastes under these conditions acted as a toxic agent.

The crude, unicellular green algae culture gave by far the best results. This might be attributed to the uniform distribution of the plants and the proximity of the plant cells to the eggs. Nitrogenous wastes were thus utilized as they diffused from the egg surface. With the macroscopic plants, the transport of these substances to the plants is limited by rate of diffusion in the undisturbed water. Rate of diffusion might not be high enough, under these conditions, to eliminate the accumulation of toxic concentrations of these substances around the eggs.

The effect of light on fish eggs might be harmful to at least some species (Smith 1957: 336). Eisler[1] found that both chinook and silver salmon eggs were sensitive to high light intensities. Chinook eggs, however, were much more sensitive than silver eggs. Use of 88 foot-candles of artificial daylight reduced the percentage hatching of chinook eggs to about one-fourth of the percentage obtained when eggs were kept under 0.02 foot-candle. The percentage of silver salmon eggs hatching under 86 foot-candles did not differ much from the percentage hatching under 0.02 foot-candle. Use of 157 foot-candles, however, proved lethal to both species. In our experiment, the light of the table top was about 150 foot-candles. The intensity reaching the eggs was only a fraction of this, owing to shading by the plants.

The procedure as described will not be adequate for those species whose eggs are very sensitive to light. A recirculating system, with an illuminated compartment containing attached plants and a shaded compartment containing the eggs, might be workable for such species.

Successful rearing of silver salmon eggs from fertilization to yolk absorption in a

[1] Eisler, R. Some effects of visible light on hatching mortality and early growth of salmonoids. M.S. thesis, 1957. University of Washington, Seattle.

small volume of water offers possibilities for many physiological experiments which are not practicable when a continuous flow of water is used. Bacteria-free fish could easily be reared by using sterilized eggs and a bacteria-free algal culture. Such fish will be of value, especially in studies on vitamin requirements and other nutritional problems.

The possibility of utilizing the principles of this procedure for large-scale hatchery process is now under investigation. Using a relatively small volume of water will make possible the control of temperature, which is important, especially for fish hatcheries in Alaska.

Summary

A simple procedure for hatching salmonid eggs in small volumes of nonflowing water is based on the balanced-aquarium principle. The eggs are kept together with green plants under continuous illumination. Of several plants tried, a unicellular green-algae suspension gave the best results.

Acknowledgments

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ADVANCE IN USE OF PELLETED TROUT FOOD

The substitution of pelleted trout food for the traditional meats and meat-grain mixtures has marked the most drastic change in the operation of fish hatcheries in recent years. In 1955, Federal hatcheries purchased 489,062 pounds of pelleted trout food, about 1.6 million pounds of dry feeds, and more than 3.7 million pounds of meat and fish products. In 1957, Federal hatcheries used, or purchased for use, almost 1.5 million pounds of pelleted trout food, about the same quantity of dried grains, and more than 3 million pounds of fresh meat and fish products.

The actual feeding of pellet foods is not the only remarkable phase in the changing hatchery picture. Whereas formerly the laborious and time-consuming activities involved in preparing fish food were regarded as a major part of the duties of the fish-culturist, today most of those tasks are dismissed as obsolete and inefficient procedures.

For the most part, pellet foods are based on variations of the formulas used previously for dry feed mixes, with fortifying ingredients added. Experiments are being made, however, to increase the efficiency of the pellets. Brown trout held on a pellet diet for 2 years at the Eastern Fish Nutrition Laboratory at Cortland, New York, are showing signs of distress; but there is reason to believe that further work on pellets will make their contribution to hatchery production still greater.

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MARKING CHINOOK SALMON FRY

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and
J. M. Shelton, Bureau of Commercial Fisheries, Portland, Oregon

THE SPRING CREEK Fish-Cultural Station (Underwood, Washington) of the Bureau of Sport Fisheries and Wildlife is one of the most successful chinook salmon hatcheries. For many years this station's annual releases of several million fall chinook salmon fry just ready to start feeding and several million fingerlings reared from 60 to 100 days have produced excellent returns of adult salmon to the hatchery. The question that arose was whether the fry or the fingerling plants produced the greatest number of adults.

At present the only practical method of marking small salmon so that they may be recognized when they return as adults is the excision of one or more fins from the young fish. In the past many fingerling chinook salmon at Federal hatcheries on the Pacific coast have been marked in this manner. The marking was done on salmon that had been fed for several weeks or months, and these fish were usually from 2 to 4 inches long when they were marked.

This marking of young fish by removal of fins is an accepted and successful tool of fishery management; however, to our knowledge, the marking of salmon fry never before has been considered entirely satisfactory. To determine whether unfed salmon fry about 1.5 inches long could be successfully marked in this manner, we excised fins on a few hundred fry of the 1955 brood and held the fish in the hatchery for several months to observe the extent of fin regeneration. Several combinations of two-fin marks ordinarily used were applied to the experimental fish.

Marking chinook salmon fry at the Spring Creek fish-cultural station.

About 7 months after being marked, the fish were examined and the quality of the mark was determined. The excised fins were graded into three categories defined as follows: "Good"--no, or very slight, regeneration; "Fair"--some regeneration but easily recognizable as an excised fin; "Poor"--much regeneration or no recognizable mark. The results of the examination are shown in table 1. From these data it was apparent that the only

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Mr. Shelton was formerly employed by the Bureau of Sport Fisheries and Wildlife.

acceptable two-fin marks were the right or left pectoral and adipose. These marks were applied in a full-scale marking project with 1956 brood fall chinook salmon fry at the Spring Creek hatchery.

TABLE 1.--Condition of excised fins on 1955 brood fall chinook salmon fingerlings 7 months after marking

Condition	Fins excised				
	Dorsal	Adipose	Anal	Ventral	Pectoral
	(percentage of total)				
Good-----	21	87	44	24	92
Fair-----	32	8	30	42	7
Poor-----	47	5	26	34	1

Fourteen women were employed to do this marking. Most of these fish markers had had experience in finclipping or tattooing fingerling salmon. The fry to be marked were taken directly from trays and placed in open troughs before the markers. The fry still had a small amount of unabsorbed yolk but were able to swim up off the bottom of the troughs. Between January 21 and February 5, 1957, a total of 242,952 unfed chinook salmon fry were marked by clipping the adipose and left pectoral fins. These fry were released into the Columbia River on the night of February 5. At the time of their release the young salmon averaged 1,077 fish per pound and 1.4 inches in total length.

Between February 6 and February 18, 1957, a total of 244,310 chinook salmon fry were marked by clipping the adipose and right pectoral fins. These fish were fed for the first time on February 11. When the marking was completed, the salmon were placed in a rearing pond. They were held until May 7, 1957, when they were released into the Columbia River. The fish averaged 121 per pound at the time of their release.

In general, marking procedures were similar to those used for salmon fingerlings in this area. Each marker caught 10 to 20 fry in a small hand net, drained off the excess water, and then placed the net over a small enameled pan so that the fish were immersed in a solution of about 1:7,500 tricaine methanesulfonate (M.S. 222). As soon as the fish began to turn over because of the effects of the anesthetic, the markers started clipping the prescribed fins. When all of the remaining fish were on their sides, the net was placed over the trough so that the fish were in running water. If the marker gauged her marking speed and the number of fish correctly, the last fish in the net was marked just before it recovered from the anesthetic. All marked fish were placed in running water immediately after being marked.

Each marker used a separate hand tally to record the number of fish marked. Each tally was enclosed in a pint-size plastic freezer bag which was closed with a rubber band. The bags kept the tallies reasonably dry and greatly reduced the time required for cleaning and repairs. The bags did not interfere with the operation of the tallies, and the totals recorded could be read easily through the transparent plastic.

A fresh solution of M.S. 222 was prepared each morning and afternoon. In midmorning and midafternoon a few ounces of fresh solution was placed in each of the pans. All of the used solution was discarded at noon and at the end of work in the afternoon. This replacement of the anesthetic was necessary because of dilution with water from the net and warming from the air in the hatchery. The M.S. 222 used in marking 487,000 fry cost about $50.

The fins were excised with cuticle clippers that were 4 inches long and had a 3/8-inch cutting edge. These clippers were smaller than those ordinarily used when marking larger fingerlings.

The main innovation in marking these fry was the use of magnifiers. Each marker was supplied with a magnifying glass, 3.5 inches in diameter, mounted on a flexible arm so that the glass could be adjusted to the most convenient position. During the marking operation the marker held a fish in one hand a few

inches below the glass. The magnifiers aided materially in observing the fins during the marking, and it is doubtful that satisfactory marks could have been placed on such small fish without this instrument.

Although these chinook salmon were small and had not completely absorbed the yolk material, mortalities from the handling and marking were very low. During the marking of the group liberated as fry, there was a mortality of 0.56 percent from the start of marking until the fish were released. This mortality included fish killed by the marking, by the anesthetic, by nets and other equipment, and a few fish that were incorrectly marked and destroyed. The group marked as fry and then reared in a pond had a total mortality of 1.05 percent from the start of marking until the fish were released 91 days later.

Marking these small fry took more time than is required for larger fingerlings. On the first group marked, the average number of fish per marker-hour was 234, or 1,872 fish per 8-hour day. On the second group, the markers increased their speed and averaged 269 fish per hour, or 2,152 fish per day. The following spring the same women, marking fingerling chinook salmon, averaged about 3,300 fish per day.

At the time these salmon fry were marked, they were so small that it was difficult to determine the quality of the marks. Five hundred fish of each mark were placed in a small rearing tank and held until the fins and scars could readily be seen. These fish were examined on June 12, 1957, at which time they averaged 3.5 inches in length. The condition of each excised fin was determined and placed in one of the three classes previously described. The results of this examination are shown in table 2.

TABLE 2.--Condition of excised fins on 1956 brood fall chinook salmon fingerlings 4 months after marking

Mark	Number of fins		
	Good	Fair	Poor
Ad-LP			
Adipose----------	471	3	2
Left Pectoral----	462	12	2
Ad-RP			
Adipose----------	474	2	2
Right Pectoral---	466	10	2

In all instances when a fish had one "poor" fin, the other marked fin was found to be "good." If the sample was representative of the entire group of marked fish and if there was no further fin regeneration, 0.8 percent of the returning adult salmon will have single fin marks and 99.2 percent will be identified easily as double-fin-marked fish.

Marking of chinook salmon fry appears to be successful, and it is planned to continue the program for several successive years.

The hematocrit reading of the percentage of packed cells in the peripheral blood may replace the red-cell count as a means of detecting anemia in fish. The red-cell count is a time-consuming procedure unless the worker has had much experience, whereas even a relatively inexperienced worker can do 20 to 30 fish hematocrits in an hour.

Of the five Pacific salmons on the North American continent, Oncorhynchus nerka is the only one about which there is no doubt that it can successfully maintain populations wholly in fresh water.

OPERATION FISH RESCUE

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MANY OF MINNESOTA'S SHALLOW LAKES are not capable of supporting fish over winter; so saving thousands of northern pike from winterkill has developed into a large-scale fishery-management program.

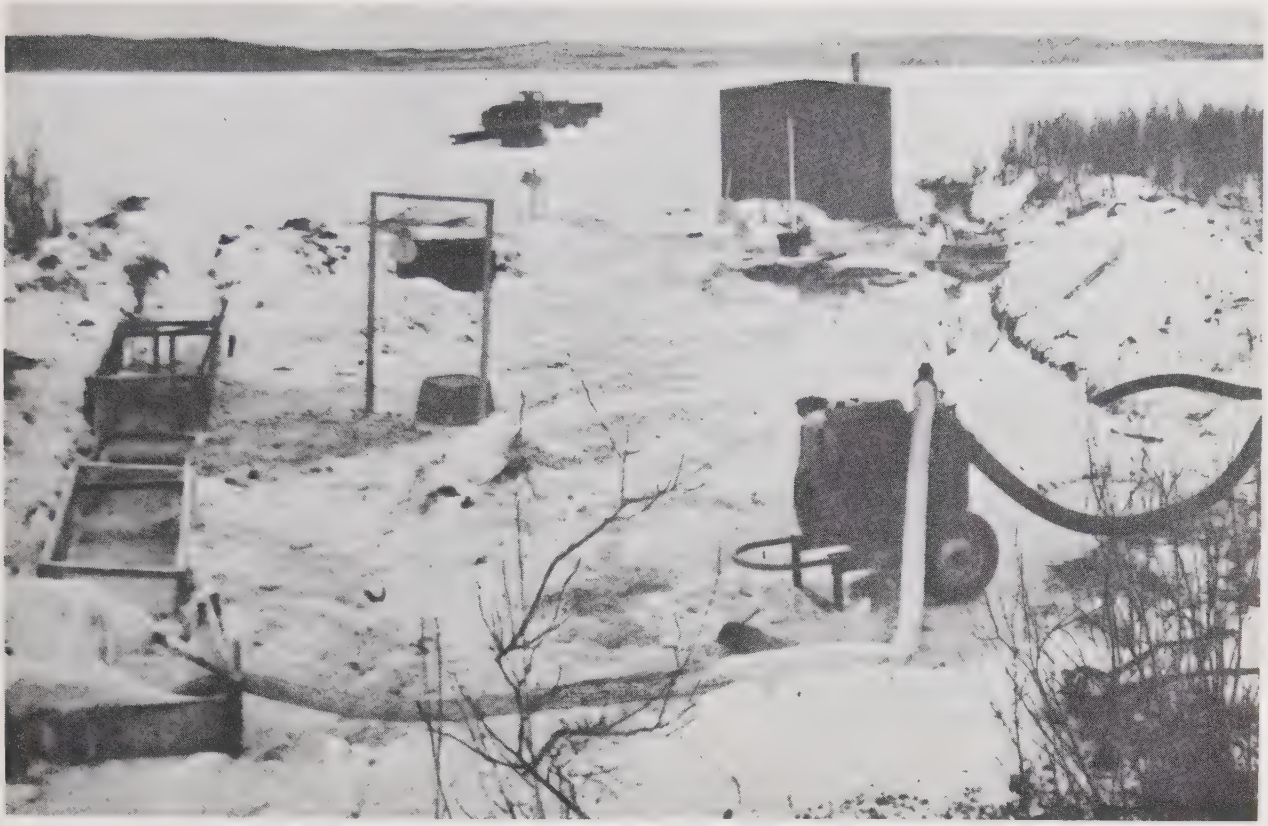
Northern pike rescued from many shallow "freeze-out" lakes are now being used effectively for control of populations of panfish and perch, and rescue operations have been expanded by the addition of two crews under the Dingell-Johnson (Federal Aid in Fish Restoration) program for not only rescue operations but also population control (the removal of surplus panfish from lakes). Improved methods for harvesting the young-of-the-year, as well as the adults, are the keys to successful rescue operations.

Snowplows are mounted on four-wheel-drive trucks to gain access to some lakes. Portable water pumps are used in effecting artificial circulation of water to and from the lakes, and trap nets are constructed for open-water fishing. With this equipment and additional manpower, we are able to take care of much of our annual winterkill problem.

With temperatures dropping to 30° below zero, causing the formation of a solid 20- to 30-inch covering of ice, plus a heavy blanket of snow, the oxygen supply is soon exhausted in shallow lakes. These shallow lakes are all sizes--from small potholes to bodies of several thousand acres--and average from 2 to 5 feet in depth. Most of these waters have considerable vegetation; some of them are almost solid with wild rice, which makes for excellent spawning conditions for the northern pike. During the spring runoff, northern pike, rough fish, and miscellaneous other fish find their way into these areas. The shallow lakes provide opportunity for multiple use in their management for waterfowl, furbearers, wild rice, and the rearing of fish.

The most effective method of winter fish rescue is unique. Portable water pumps with a rated capacity of 20,000 gallons per hour are used to circulate water through artificially created inlet and outlet creeks. It is important that the sites be located and the channels be installed before winter begins. Ditching dynamite provides a simple means of excavation, and artificial ditches are made in the shoreline near the deepest area of the lake where vegetation is more sparse. These ditches provide space for fish to assemble and are usually made in the portion of the lake most likely to retain oxygen longer.

Two channels, about 150 feet apart, are dug back from the shore to simulate an inlet-and-outlet stream. These channels are 3 feet wide, have 2 feet of water, and are about 50 feet long. Rectangular screen traps, 3 feet by 3 feet by 8 feet, with a throat facing the lake, are placed in each ditch about 30 feet back from the lake. At the terminal point of one channel, a suction hose is placed. The pump discharges water through a hose and into a wooden box, 4 feet by 4 feet by 3 feet, at the terminal point of the second channel. The box serves a twofold purpose: it builds up oxygen in the water and prevents the



churning of mud and debris. Between the discharge box and the trap there is installed a screen holding box where fish can be collected and kept alive by the supply of oxygen-fortified water.

The operation of these pumping units for fish rescue is simple. The flow of water and the buildup of oxygen attract fish into either the inflow or the outflow channel. The pattern of reaction differs from one season to another. During the season of 1955-56 on Laura Lake in Cass County, 80 percent of the fish came into the inflow channel. During the season of 1956-57, about 80 percent came into the outflow channel.

At the beginning of operations, the oxygen reading in the lake is 2 p.p.m.; as the season progresses, the oxygen declines to 0.0 p.p.m. Fish are able to survive for a long period of time with practically no trace of oxygen. Controlling the discharge of water from the pumps is important. A buildup of too much oxygen will cause the fish to stay out in the lake. Slowing down the pumps, as well as sometimes stopping them for several hours, is necessary to attract the fish into the traps. As the harvest nears completion, the pumps are operated only 2 or 3 days a week in order to allow the fish to congregate in the area. Finally, when the northern pike are nearly all removed, a few bullhead begin to appear in the traps, an indication that the oxygen in the lake has been exhausted.

Screen traps set in spring holes and outlet streams have also proved effective in fish-rescue work. Fish attracted to spring holes are taken in traps which have been dug into the bank. One or several throats are provided to allow fish to enter the trap from the sides and the front. A trap set in an outlet stream is a simple rectangular box with a throat facing upstream and wings to each shore. Fish that are in danger of suffocating retreat from the lake as the oxygen starts to go. As the fish travel downstream, they enter the traps, where they accumulate until

they are removed. Several traps can be handled by a two-man crew making daily or periodic collections of fish for distribution.

Open-water trap-netting is done during the fall to harvest the largest fingerlings and the adult fish which still remain in the lake. The trap nets are of 3/4- or 1-inch bar mesh webbing. Nets of smaller mesh cannot be used because they are too dark to attract fish and thus are not effective.

In larger lakes, more than 100 of these nets are set. They are located close to shore and set in strings wherever there are narrows. Nets are lifted daily during the early part of the season; as the water becomes colder, lifts can be made twice a week. Stock tanks in boats and barges are used to collect the fish for hauling to the landing. Net cribs are sometimes used to assemble all the fish collected during the day so that the distribution units have a full load available when they arrive.

Northern pike taken in rescue operations vary a great deal in size. In some lakes the average size is 2 pounds each; in others, 12 fish per pound. Most of the northern pike taken by the pumping method during the winter average 6 fish per pound. They are in excellent condition and can be handled with no loss in cold water. Distribution is made with oxygen-equipped wood tanks that offer insulation against extremely cold temperatures.

Laura Lake in Cass County is a good example of what is being accomplished by fish-rescue work in Minnesota. During the season of 1955-56, a total of 52,699 northern pike, weighing 20,861 pounds, was harvested from this 1,454-acre lake.

With many more lakes producing large numbers of fish, these operations have provided an effective means of management stocking.

STRIPPING PROCEDURES IN AN AUSTRALIAN FISH HATCHERY

Situated about 86 miles northeast of Melbourne, in Victoria, Australia, the Snobs Creek Fish Hatchery of the Fisheries and Game Department has developed very effective methods of taking eggs and milt from its rainbow and brown trout.

The practice at many trout hatcheries is to have the spawntaker run his thumb and forefinger along the belly of the fish and literally force out the eggs (or milt). If the spawntaker applies too much pressure, the eggs may be damaged to such an extent that they cannot be fertilized. Faulty spawntaking techniques have often resulted in lowered percentages of eyed eggs. The stripping methods developed at Snobs Creek, however, have been so successful that, as a general rule, nearly 100 percent of the eggs are fertilized.

The stripping of female fish at Snobs Creek requires use of a sterilized hypodermic needle that is connected by a long tube to a bicycle pump. The needle is pushed quickly through the thin wall of the belly of the fish. Air is then pumped through the needle into the fish, with the result that the eggs (which lie loose in the body when they are mature) are gently expelled through the vent. After the eggs have been expelled, the air in the body of the fish is carefully removed through the tube. This removal is effected by the operator's placing the end of the tube in his mouth and drawing out the air--a procedure that permits easy control of the pressure.

Male fish at Snobs Creek are stripped by suctioning the milt into an airtight vial. A sterilized hypodermic needle connected by tube to the vial is gently inserted into the spermaduct. With a second tube to the vial held in the operator's mouth, the fertilizing fluid is then drawn from the fish.

TOXAPHENE (CHLORINATED CAMPHENE) AS A SELECTIVE FISH POISON

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FIVE LAKES, KNOWN AS THE SAND LAKES, located in Grand Traverse County in northern Michigan, were treated with 0.010 to 0.025 p.p.m. of emulsifiable toxaphene concentrate in October 1956. While gathering dead and dying fish, the authors noted that at these low concentrations of toxaphene small fish died before the large fish. These observations suggested that a lower dosage of toxaphene would eradicate small fish and not injure the larger individuals. To test this hypothesis, Roots Lake, in Grand Traverse County, and House Lake, in Gladwin County, were treated with toxaphene at concentrations near the 10-day median tolerance limit for goldfish (Doudoroff, Katz, and Tarzwell, 1953).

Roots Lake has an area of 15.6 acres and a maximum depth of 18 feet. The bottom is marl, sand, and pulpy peat and supports few submerged plants. A concentration of 0.002 p.p.m. of toxaphene applied to the epilimnion of Roots Lake failed to kill fish.

The remainder of this paper will deal only with the experiment on House Lake. This lake has an area of 4 acres. The littoral zone is covered with snags and deadheads and supports a sparse growth of aquatic plants. The bottom is composed of sand and pulpy peat. The water is hard (methyl orange alkalinity, 130 p.p.m.).

Contribution from the Institute for Fisheries Research.

On the afternoon of July 25, 1957, House Lake was treated with 0.005 p.p.m. (5 parts per billion) of emulsifiable toxaphene concentrate. This concentration was calculated only for the water volume of the epilimnion. The toxicant was applied--after the concentrate had been diluted about a hundredfold--by dripping the diluted emulsion from a speeding boat powered with an outboard motor.

Before and after the treatment, the large fish were sampled with 5 gill nets of various mesh sizes (1.5- to 3-inch stretched). Nets were set overnight in water 5 to 15 feet deep. An attempt was made to set the nets at identical localities and depths before and after treatment, on July 24 and August 1, respectively. Before treatment, the 5 gill nets caught 26 bluegill averaging 4.3 inches in length. One week after treatment, the same netting effort yielded 29 bluegill averaging 4.7 inches, 4 yellow perch averaging 6.2 inches, and 1 largemouth bass 9.9 inches long. These results indicated that the larger fish were not affected by the toxicant at the concentration used. This belief is supported by the authors' failure to find any dead fish (largemouth bass, bluegill, and carp) of large size during frequent observations after treatment.

The effect of the toxicant on small fish was indicated in part by shoreline seining before and after treatment. Twenty hauls with a 30-foot straight seine, 1.25-inch bar mesh, were made on each of 4 days, July 24 and July 25 (before treatment) and August 1 and 2 (1 week after treatment).

The extremely poor catch on the 2 days of seining after treatment (see table) indicates that few small fish had survived.

The extensive mortality of small fish and the survival of larger fish indicated by seining and gill netting were confirmed by direct observations. On the day after treatment centrarchids from 0.5 to 1 inch long were observed dead and dying along the east shore. A week later numerous dead sunfish up to 2.5 inches long were noted along the shore. At this time a few small bluegill were still alive, although they clearly showed distress symptoms. Specimens captured in seine hauls on August 1 and 2 (a week after treatment) were in this condition. Two weeks after treatment no dying fish were observed, though healthy largemouth bass and large bluegill could be seen along the shore. On September 13 several largemouth bass up to 14 inches long and 3 pumpkinseed about 3 inches long were observed.

These results suggest that a concentration of 5 parts per billion of toxaphene can be used to reduce the population of small fish in hard-water lakes without greatly affecting the population of large fish. Further tests are planned to determine whether these results can be duplicated on lakes of different size, bottom configuration, and water hardness.

NUMBERS OF FISH TAKEN IN 20 SEINE HAULS ON EACH OF 4 DAYS IN HOUSE LAKE, MICHIGAN

Species	Before treatment		After treatment	
	July 24	July 25	August 1	August 2
Bluegill	448	363	5	1
Pumpkinseed	14	6	1	1
Largemouth bass	5	---	---	---
Yellow perch	1	---	---	---
Rock bass	---	1	---	---
Total	468	370	6	2

Literature Cited

Doudoroff, Peter, Max Katz, and C. M. Tarzwell
1953. Toxicity of some organic insecticides to fish. Sewage and Indus. Wastes 25 (7): 840-844.

During 1957 research assistants of the Oregon Cooperative Wildlife Research Unit demonstrated that small amounts of zinc had a significant effect on hatchery-reared trout. Fish that were held for 6 hours in water containing 1 milligram (or less) zinc per liter suffered delayed losses in direct relationship to the concentration of zinc present. At concentrations of 1.8 milligram (and above) per liter, all test animals died either during the experiment or immediately after its termination.

In writing your acknowledgment, if any, make it warm, but not "Uriah Heepish." Do not give credit to your fellow workers for doing routinely what they were hired to do. Typing your manuscript, for example, does not ordinarily call for an acknowledgment. Neither do the supervisory and the administrative services of project leader, laboratory director, or other official, regardless of how essential these services were. If an acknowledgment is to have meaning, it should be reserved for aid of an exceptional character. -- F. B. Sanford: Planning Your Research Paper. U.S.D.I., Fish and Wildlife Service, Fishery Leaflet No. 447.

TERATOLOGICAL HERMAPHRODITISM IN THE CHUM SALMON, *ONCORHYNCHUS KETA* (WALBAUM)

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THE ANOMALOUS CONDITION OF HERMAPHRODITISM appears to be no less rare in fish than in other normally dioecious animals. Previous records of bisexuality in the Pacific salmons, Oncorhynchus spp., are few in number despite the intensive study accorded this group. Rutter (1902) reported the condition in two king salmon (O. tshawytscha); Crawford (1927) reported the condition in a silver salmon (O. kisutch); and Gibbs (1956) described a bisexual steelhead trout (Salmo gairdneri) and briefly noted another instance of hermaphroditism in the king salmon. We wish to record an example of this anomaly in the chum salmon (O. keta).

The specimen was 1 of 40 upstream-migrant, sexually mature chum salmon captured in the Chitose River, Hokkaido, Japan, in October 1956. These fish were supplied to us through the courtesy of the Japanese Fishery Agency for use in current parasitological studies. The aberrant specimen measured 69 centimeters in fork length and displayed the typical nuptial coloration and form of a breeding male. Subsequent dissection revealed the atypical condition of bilateral ovotestes.

In gross appearance the gonads are predominantly male organs. Each is a well-defined entity terminating in a normal male efferent duct. The two differ considerably, however, in size and degree of development of their respective male and female parts (figures 1 and 2). The anterior third of the left ovotestis consists of a relatively well-developed mass of

FIGURE 1.--Dorsal view of the left and right gonads of a hermaphroditic chum salmon.

FIGURE 2.--Enlargement of figure 1, showing anterior gonadal detail.

(Photographs by T. O. Duncan)

ovarian tissues containing aggregates of immature ovocytes; the posterior portion appears as a weakly developed, but seemingly functional, testis. The right gonad has the superficial appearance of a normal testis. Anteriorly, however, its bisexual nature is evident in the presence of a very small, closely applied ovarium. Although the total mass of this ovarium is significantly smaller than its counterpart, comparable ovocyte development indicates a similar state of physiological activity. The preponderance of male tissue and the regular appearance of the terminal ducts suggest that the specimen should be classified as a true male exhibiting latent, nonfunctional, female characteristics.

The rarity of hermaphroditism in chum salmon may be surmised from the fact that the case reported here is a single instance among more than 2,000 examinations made in this laboratory. The gonad material has been preserved and is deposited in the fish collection of the University of Washington, College of Fisheries (Accession Number 11404).

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1927. Notice of hermaphroditism in silver salmon, Oncorhynchus kisutch. Copeia 163: 34.

Gibbs, E. D.
1956. A bisexual steelhead. Calif. Fish and Game 42 (3): 229-231.

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1902. Natural history of the quinnat salmon. Bull. U. S. Fish. Comm. 22: 65-141.

LIVING RESOURCES OF THE SEA

Lionel A. Walford
xv, 321 pp., illus. The Ronald Press Company, New York. 1958. $6.

The subtitle, "Opportunities for Research and Expansion," is a fair characterization of this unusual book by the former chief of fishery biological research of the U. S. Fish and Wildlife Service. The author concludes, quite realistically, that the opportunities for research are far greater than the opportunities for an immediate, or even an early, expansion of the harvest from the sea.

The book is addressed, the author says, "to everyone who is interested in the rich possibilities of the marine wilderness," but he hopes it will be helpful and stimulating to fishery scientists and students and to members of the fishery industry.

The book is unusual in asking more questions than it answers. Perhaps space considerations, perhaps the many books on the subject which have appeared since Carson's - Sea - Around - Us became a best seller, moved the author to avoid repetition of the mass of natural history on fish and marine life--at any rate, many of the chapters are relatively barren of factual information. Yet, the author's evident aim is realized. He conveys the impression of vast areas of the world ocean which are still virtually unknown except in superficial or scattered aspects, of still other vital areas where knowledge is too incomplete to have much practical, i.e., economic, significance.

Each chapter is introduced by a short foreword which serves not only as a condensed summary but also as a welcome introduction to the following subject matter. This orients the reader and makes reading and understanding easy and pleasant.

Part I, The Marine Wilderness, includes seven chapters which discuss the applications of the various sciences to

fishery science. They constitute a rather straightforward review of the general field, pointing out the need for filling the many gaps in knowledge of these subjects. The chapter on the geography of fisheries and worldwide distribution of our fishery knowledge would have been vastly improved had the author employed a more familiar form of world map.

Chapters 8 to 12 constitute an uneven treatment of mostly unrelated but much-discussed subjects: The Dream of Harvesting Plankton, Farming the Brackish Waters, The Role of Disease, Poison (i.e., poisonous fishes and plankton), and Improvement of Fishing Vessels and Gear. In these chapters the author again points out our ignorance rather than what is known. The last of these chapters, on fishing vessels and gear, contains a fuller account of what is known than the others do.

Part II is a condensed account of the principal Resources of the Sea, presented in five chapters. Considering the restricted space allotted to this area of knowledge, the facts, ideas, and conclusions are well balanced, reliable, and satisfying.

The final chapter, Looking Forward, is original, at many points inspiring, and always satisfying in summing up as well as in pointing out. The last paragraph is worth quoting:

> But why put up with such antiquity? Why should not technologies and philosophies advance? If we learned how to use the sea resources fully and scientifically, the material rewards should well compensate for all the investment that would be required for the learning. There is no way of evaluating these rewards now. Nor can anyone honestly promise that they will in fact be forthcoming, any more than anyone could once have promised the ultimate use of atomic energy. There is no simple, direct short-cut to a full understanding of the proper uses of the sea. The most economical, efficient way to reach that understanding is not to try to do it penuriously. If we really desire to exploit the sea fully, if it is knowledge that we need to accomplish that purpose--and that is the theme of this book--then we had better make the necessary costly investment and put full effort into the job of acquiring that knowledge.

The style is clear and direct; the diction is rich and sure. The text is remarkably free from rhetorical or typographic errors and is free from distracting footnotes--which is unusual in a review of great masses of source material. All references are collected, by chapters, at the end of the book, where there is also an index.

The book will be invaluable to the graduate student (and his professor) and to the professional fishery scientists as a source of inspiration.

---ELMER HIGGINS, Bureau of Commercial Fisheries, Washington, D. C.

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